New Scientist

WEEKLY 20 July 2024

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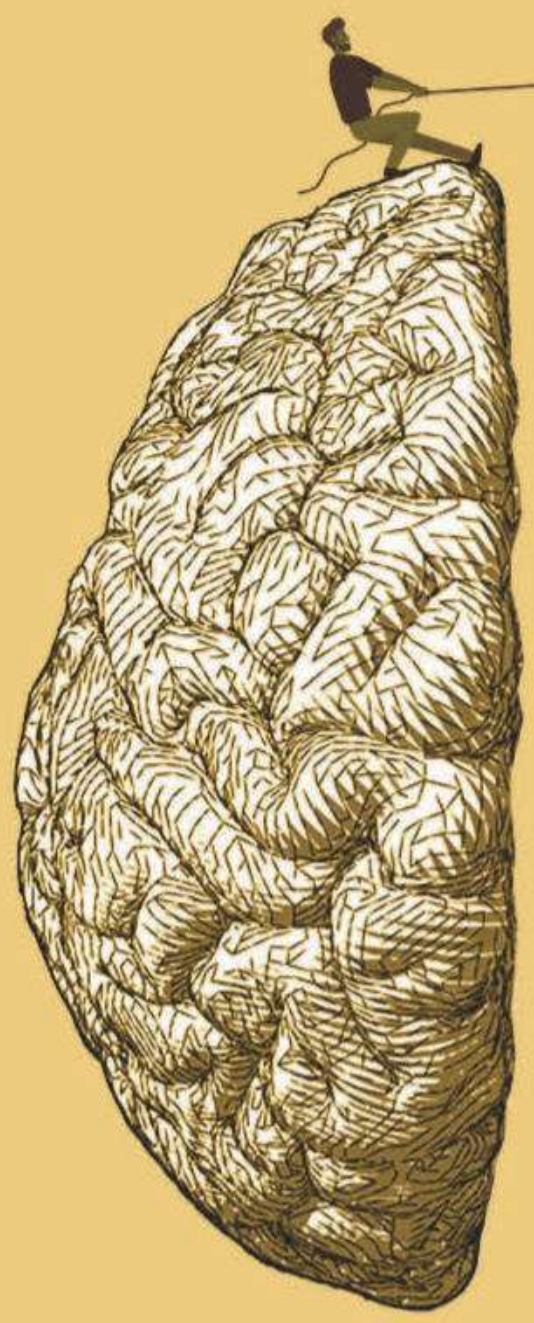
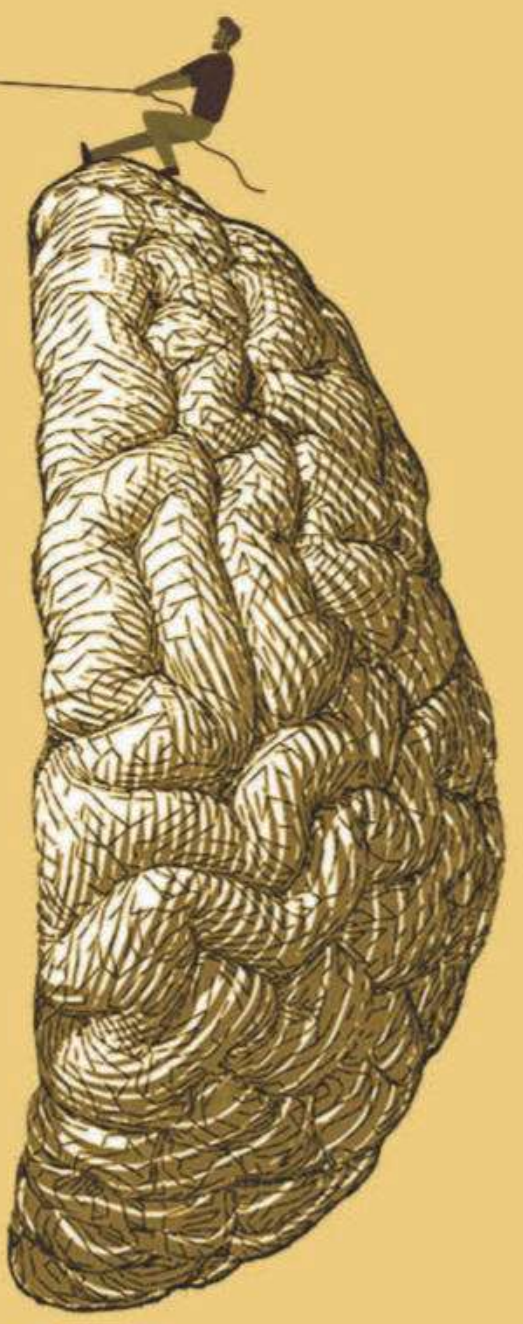
CAN WE PREVENT GPS ATTACKS ON PLANES?



YOUR MIDLIFE BRAIN

Why middle age is the perfect time to take control of your cognitive health



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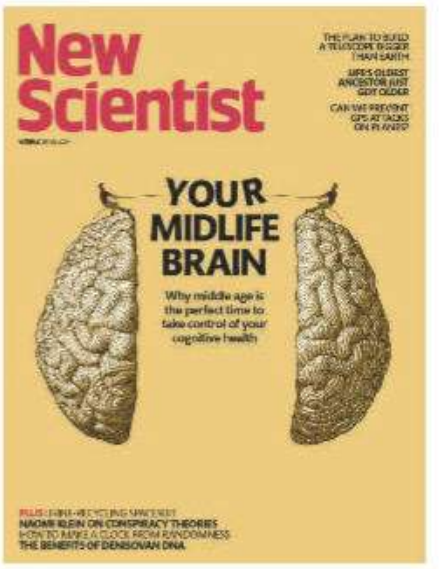

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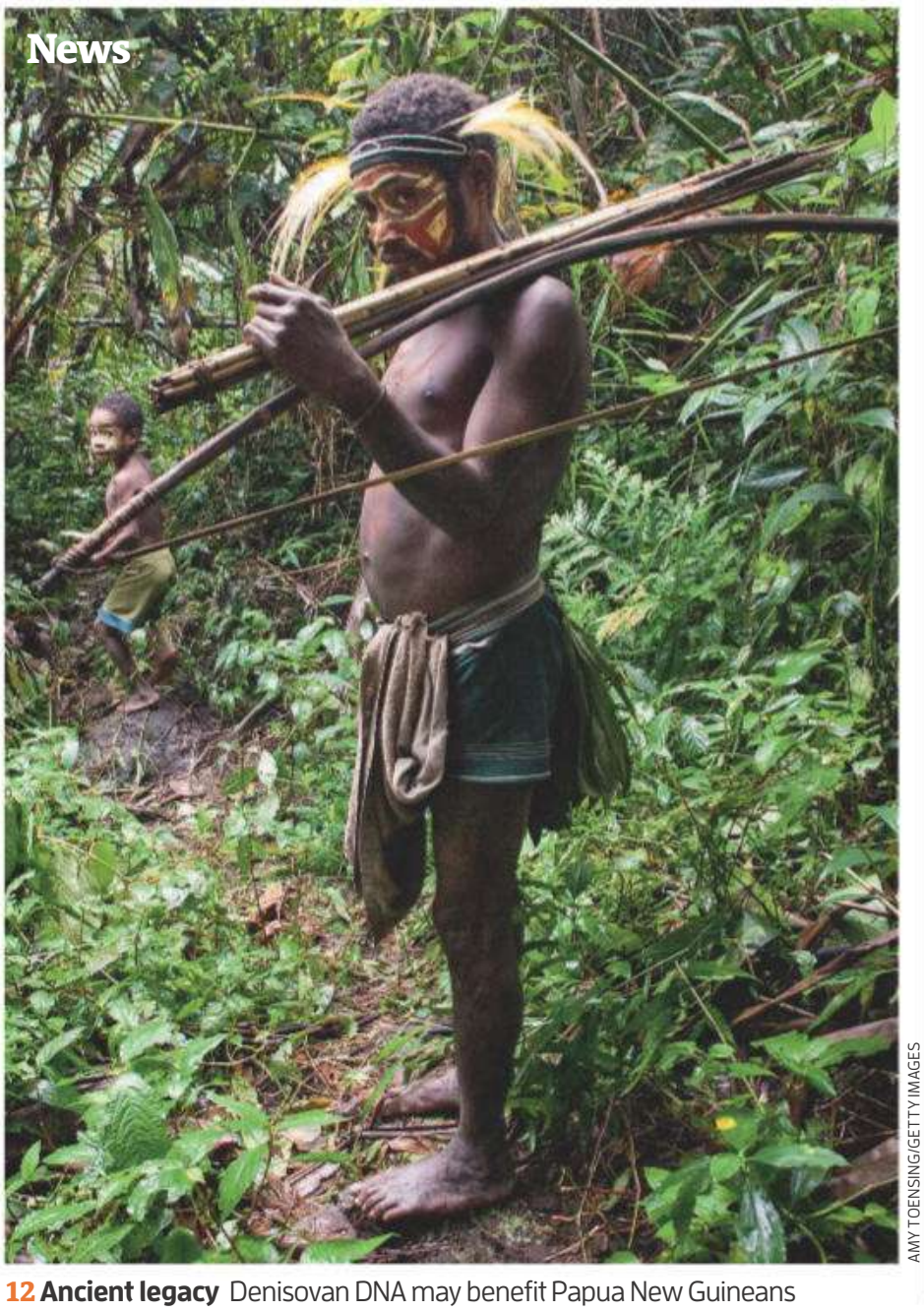

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Elsewhere on New Scientist

NS Live

Hungry brains

At this year's festival, psychologist Kimberley Wilson will explain why your brain is the hungriest organ in your body, requiring a constant supply of energy. The food we eat can affect everything from IQ to aggression, so what are the key nutrients for brain health and what happens if we don't get the right mix? Find out at New Scientist Live on 12 October at London's ExCeL Centre or watch online.

newscientist.com/nslmag

Tour

The science history of Scotland

Learn about Edinburgh and Glasgow's most famous scientific thinkers and discover how their ideas advanced our understanding of the world from the 16th century onwards. Enjoy expert talks and explore key sites from the Scottish Enlightenment. This five-day tour begins on 5 September and costs £1395.

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Podcast

Dead Planets Society

This week in the podcast that imagines tinkering with the cosmos, hosts Leah Crane and Chelsea Whyte talk about primordial black holes. These are tiny versions of their bigger cousins and are so small that they could easily fit inside a planet or a star... or a person. So could you put primordial black holes inside things, and what chaos would ensue if you did?

newscientist.com/nspod

Newsletter

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Bipedal ancestor? It is unclear quite how *Sahelanthropus* walked

SHUTTERSTOCK/RICHIE CHAN

Sumptuous skyline Learn more about Edinburgh's scientific heritage

Video

Scanning buildings

Reporter Madeleine Cuff caught up with the researchers behind a modified Tesla car that is scanning the UK's buildings. The idea is to map how they trap heat and how it escapes, giving us crucial knowledge about where we need to focus our insulation efforts to get the most bang for our buck. Watch the video online now, together with other great exclusives.

youtube.com/newscientist

Newsletter

Our Human Story

This month, Michael Marshall writes about *Sahelanthropus*, the oldest recorded hominin, which featured in the very first edition of this newsletter. Whether this creature walked on two legs – and if bipedalism is a defining feature of hominins – has long been debated. Now, the idea is being challenged again.

newscientist.com/our-human-story

Podcast

"We're talking about black holes, but not the big behemoths you might be thinking of"

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Glow-up

With a JJ04 movement capable of precisely plotting each phase of the moon for 128 years, the C1 Moonglow has always had allure. Now, it exerts an even greater gravitational pull. The twin Globolight orbs, which wax and wane across the starry, sapphire dial are more three-dimensional. And, instead of glowing green, they gleam a cool, bright blue - thanks to souped-up Super-LumiNova. (Which also lights up its orbiting date wheel, for truly stellar nocturnal legibility.) Other lustrous features include a 40.5mm LightCatcher™ case, polished lug facets and optional five-link Consort™ bracelet. Even its price is illuminating: from just £1,995 on leather.

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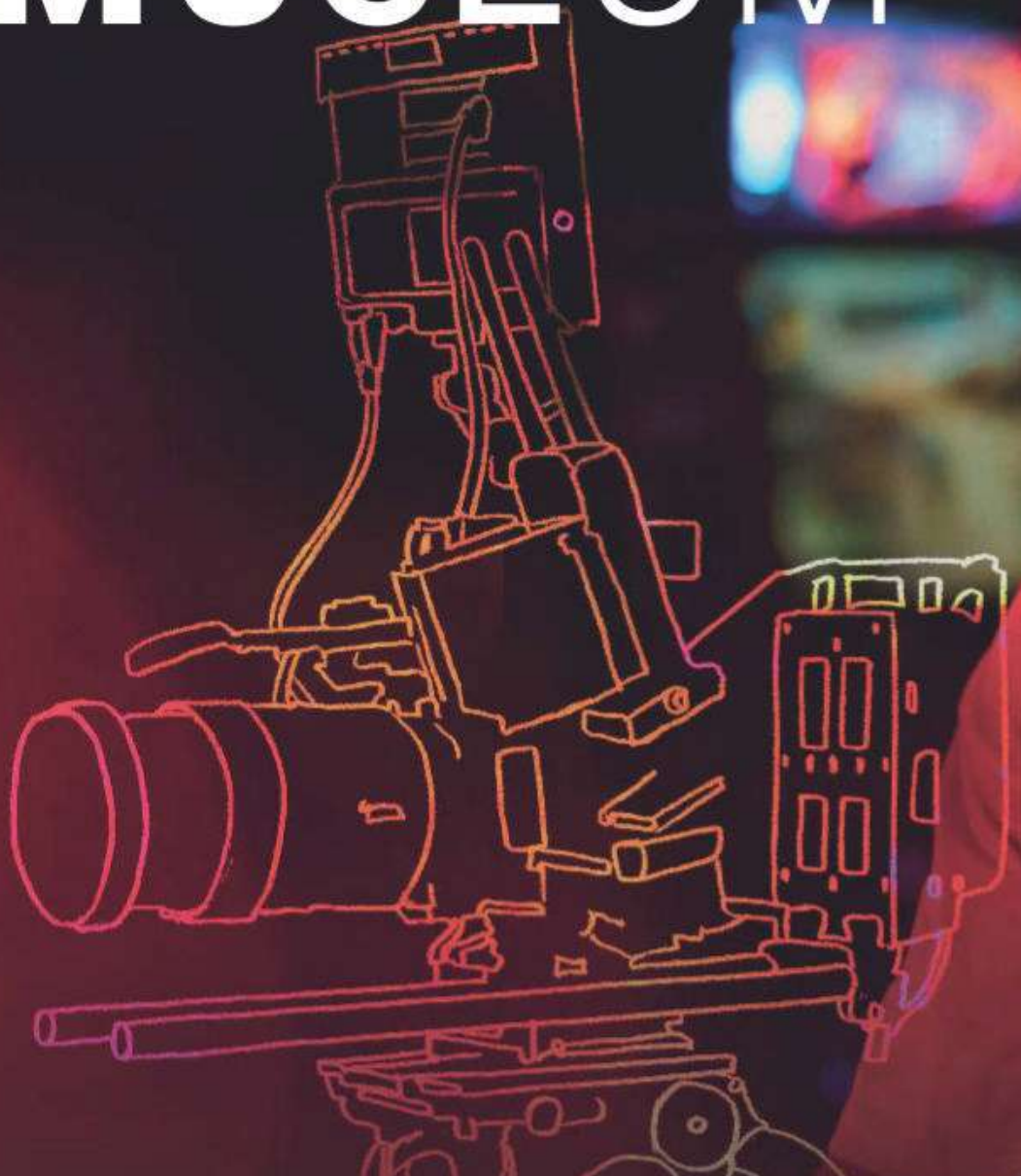

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Getting warmer

In the race to ramp up renewables, we can't afford to ignore heat storage

IT IS by now well established that to mitigate the worst effects of climate change, we need to reach net-zero carbon emissions as fast as possible. That means getting more of our energy from renewable sources and finding ways to store it for long periods to overcome the intermittency of wind and solar.

Huge battery installations and green hydrogen – where excess renewable energy is used to split water – are often touted as the most promising storage solutions, and clever new ways to hoard excess power are popping up all the time (see page 19). However, the possibilities for storing renewable energy as heat are often overlooked.

When we think about renewables, we tend to think about electricity. But heat itself is also a valuable commodity. About half of the world's total energy demand is for heat, whether for warming homes or to power the industrial production of food, medicines, materials and more. Besides, stored heat can also be used to generate electricity when the sun stops shining and the wind dies down.

"Many of these technologies are disarmingly simple, from toasted bricks to molten salt"

The good news, as we discover on page 36, is that a whole range of heat storage technologies are emerging. Known collectively as Thermal Energy Storage (TES), many of these innovations are disarmingly simple – from toasted bricks to molten salt. Crucially, they should also be affordable. Early estimates suggest that these technologies could be as little as a fifth of the cost, per kilowatt-hour, of energy storage using green hydrogen. In a recent report, the International Renewable Energy Agency said TES offers "unique benefits".

The problem is that there is relatively little awareness of TES, and even less investment. Private backers are beginning to put serious money into pilot projects in the US and Europe. But governments everywhere need to step up if we are to make good on TES's promise as a relatively easy way to make a hefty dint in renewable energy's intermittency problem. If the prices are as good as they look, we can't afford not to. ▮

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Death-defying swim
Lions cross 1.5-km channel filled with crocodiles p19

NASA, ESA, CSA, STScI

Astronomy

Dance of a cosmic penguin

In space, no one can hear you waddle. NASA has used the James Webb Space Telescope to image a pair of galaxies. Known together as Arp 142, they are nicknamed the Penguin (the large orange structure) and the Egg (the white blob to its left). The Penguin was originally a spiral galaxy, but its shape has been distorted by interactions with the Egg.

Analysis Climate change

Is a vital ocean current heading for a tipping point? Two studies suggest the Atlantic meridional overturning circulation could collapse by the middle of the century, but such predictions are controversial, says Madeleine Cuff

THE 2004 movie *The Day After Tomorrow* may have taken some serious artistic licence with climate science, but it got one thing right. Climate change may indeed cause a collapse in global ocean currents, with devastating consequences.

When the Hollywood blockbuster was made, researchers knew relatively little about the state of

"The collapse of the current could lead to a severe drop in temperatures across northern Europe"

the Atlantic meridional overturning circulation (AMOC), an ocean system that transports warm water and nutrients around the Atlantic Ocean. But there were concerns that melting ice sheets could cause this vital current to weaken, and even collapse, if lots of fresh water entered the North Atlantic from melting ice sheets.

Continuous monitoring of the AMOC only began in 2004. Before that, researchers had to make do with climate models, proxy data and sporadic real-world measurements. Most thought AMOC collapse was a remote possibility, and it certainly wasn't expected within the 21st century.

That has changed. A new study by René van Westen at Utrecht University in the Netherlands and his colleagues suggests the AMOC could tip towards collapse between 2037 and 2064, with a mean estimate of 2050 (arXiv, doi.org/m75p).

The collapse of the AMOC could lead to rapid sea level rise in North America, a sudden and severe drop in temperatures across northern Europe and serious disruption to monsoons across Asia.

This work is the second study in as many years to predict a mid-century collapse of the AMOC, following a 2023 paper by Peter and Susanne Ditlevsen, both at the University of Copenhagen, Denmark.

NASA/GODDARD SPACE FLIGHT CENTER

Visualisation of currents in the Atlantic Ocean

Melting ice sheets could cause a key current to weaken

SHUTTERSTOCK/VLADIMIR TURKENICH

Both papers use so-called early warning signals (EWS) as a guide to the future of the AMOC. These factors, including sea temperatures and the salt content of the ocean, are used in part because the actual historical record of AMOC strength is barely 20 years old, not long enough to sort the signal from the noise.

Huge uncertainties

EWS offer an alternative to climate models, which have long underestimated the likelihood of an AMOC collapse, partly because they don't fully include the impact of meltwater entering the ocean from the Greenland ice sheet.

The Ditlevsen paper uses historical sea surface temperatures as a proxy for AMOC strength. Meanwhile, the study by van Westen's team, which hasn't yet been peer reviewed, analyses historical salinity data from the Atlantic Ocean alongside the results of detailed computer simulations run by the researchers earlier this year.

The two studies came up with very similar predictions. Does this mean AMOC collapse is looking more likely this century? Yes, according to van Westen. He says his team's paper "really questions the viewpoint" of the last Intergovernmental Panel on Climate Change (IPCC) report on the topic in 2019, which rated the likelihood of an AMOC collapse before 2100 as "very unlikely".

Stefan Rahmstorf at the Potsdam Institute for Climate Impact Research in Germany says there is now enough real-world data to demonstrate that the AMOC has indeed weakened in recent decades. He also says an AMOC collapse before the end of the century is looking more likely than first thought. "I used to think, until a few years ago, that the probability in this century [of AMOC collapse] is less than 10 per cent, just like the IPCC," he says. "Now I think it is more than 10 per cent, in light of the research from the last five years or so."

But he is sceptical of papers that claim to be able to predict when a collapse may happen, in part because there is just so much uncertainty in using EWS data as a predictor of the AMOC's future behaviour. "The problem is that these studies still come up with pretty large uncertainty ranges for where this tipping point is," he says.

Niklas Boers, also at the Potsdam Institute for Climate Impact Research, insists that climate models aren't yet accurate enough, and historical data isn't reliable enough, for researchers to confidently make such predictions. "Pretending that we are able to predict tipping times just gives a very false sense of security, of certainty, that we really understand the system well enough to do such a thing. And that is absolutely not true," he says. "With these huge uncertainties, we should be even more careful, and be even more restrictive on future greenhouse gas emissions." ▮

The ancestor of everything

An organism living a few hundred million years after Earth formed gave rise to all life today

Michael Le Page

THE organism that gave rise to all life currently present on Earth may have evolved much earlier than once thought, just a few hundred million years after the planet formed, and been more sophisticated than previous assessments have suggested.

The DNA inside all organisms alive today, from *E. coli* to blue whales, has many similarities, which suggests it can all be traced back billions of years to a last universal common ancestor (LUCA). Many efforts have been made to understand LUCA, but now a study taking a broader approach has turned up some surprising results.

"What we've been trying to do is bring people representative of different disciplines together to come up with a holistic understanding of when LUCA existed and what its biology was," says Philip Donoghue at the University of Bristol in the UK.

Genes that are found in all the main branches of life today may have been passed down in an unbroken line all the way from LUCA, allowing us to work out what genes the ancient ancestor possessed. By looking at how those genes have changed over time, it should be possible to estimate when LUCA was alive.

In practice, this is much trickier than it sounds, because genes have been lost, gained and swapped between branches. Donoghue says the team has created a complex model that takes account of this to work out which genes were present in LUCA. "We come out with an organism which was much more sophisticated than many people have argued in the past," he says.

The researchers estimate that 2600 protein-coding genes can be traced back to LUCA, whereas some previous estimates are as low as 80. The team also concludes that LUCA lived around 4.2 billion years ago – much earlier than other estimates, and surprisingly close to the formation of Earth 4.5 billion years ago. "It suggests evolving life may be simpler than people have argued in the past because it occurred so early," says Donoghue.

This earlier date is partly down to what the team says is an improved method. But it is also because, unlike others, the researchers don't assume that LUCA could only have existed after the late heavy bombardment, when Earth is thought to have been pummelled by space debris, potentially wiping out any burgeoning life. This period has been dated to about 3.8 billion years ago, based on rocks brought back from the moon, but there is much uncertainty about the figure, says Donoghue *(Nature Ecology & Evolution*, doi.org/m7r3).

Because their reconstruction suggests that LUCA had genes for protecting against UV damage, it is most likely that it lived at the surface of the ocean, the researchers think. Other genes suggest LUCA fed on hydrogen, which is in line with previous studies. It may have been part of an ecosystem of other kinds of primitive cells that died out, the team speculates. "I think it's naive in the extreme to think that LUCA would have existed on its own," says Donoghue.

"I find this compelling from an evolutionary perspective," says Greg Fournier at the Massachusetts Institute of Technology. "LUCA is not the beginning of the story of life, but just the last shared ancestor state that we can work backwards to using genome data."

The results also suggest LUCA had a primitive version of the bacterial defence system known as CRISPR, to fight off viruses. "Even 4.2 billion years ago, our earliest ancestors are fighting off viruses," says team member Edmund Moody, also at the University of Bristol.

Peering back into the deep past is fraught with uncertainty, and Donoghue is the first to admit that his team may have missed the mark. "It's almost certainly all wrong," he says. "What we're trying to do is push the envelope and create the first kind of attempt at integrating all of the relevant evidence."

"It won't be the last word," he says. "It won't even be our last word on this topic, but we think it's a good start."

Patrick Forterre at the Pasteur Institute in Paris, who came up with the term LUCA, also thinks the organism wasn't living in isolation. "But the claim that LUCA was living before the late heavy bombardment 3.9 billion years ago is completely unrealistic for me," says Forterre. "I am quite sure that their strategy to determine the age and gene content of LUCA has some flaws." ▮

~3.8bn
Previous estimate for how many years ago LUCA lived

4.2bn
New estimate based on a variety of methods

4.5bn
Earth formed this many years ago

SCIENCE GRAPHIC DESIGN

Our last universal common ancestor may have been attacked by viruses

Physics

How to build a clock from any random 'ticks' around you

Karmela Padavic-Callaghan

ANY random sequence of events, such as the lapping of ocean waves on the shore, can be repurposed into a clock – and physicists have now devised a mathematical procedure that describes how to make one such example of this odd kind of timepiece.

"How can you turn anything into a clock? We decided to tackle that problem by thinking about processes that, in a way, look the least like clocks," says Mark Mitchison at Trinity College Dublin in Ireland.

A wristwatch can be used to keep time because its ticks are both regular and predictable rather than being random. But Mitchison and his colleagues imagined a situation in which someone has been stranded on a desert island without a watch, and is trying to time the cooking of their food by relying on natural processes that repeat, but not in a strictly regular fashion.

The castaway could, for instance, make a clock using ocean waves, their own heartbeat or the motion of the sun across the sky – all of which may seem regular and predictable, but actually vary slightly in a random way when you try to measure them precisely.

These processes are called Markovian, and they are composed of "jumps", or events whose timing doesn't follow any predetermined pattern. The team mathematically analysed these Markovian processes and calculated just how precisely you could extract time from a set of recorded notes about a series of jumps. This would then allow the castaway to build a clock from the many random events around them.

VIKTOR DRACHEV/AFP VIA GETTY IMAGES

Not all clocks are such obvious time-keepers

"It would essentially be a kind of counting, but more precisely," says Mitchison. "You would note: OK, a wave just came up, then my heart just beat, and then my heart beat again, then another wave."

The team came up with equations that capture statistical properties of how random jumps are distributed in time, which would make it possible to estimate how much time had passed between the events and how accurate that estimate is (arXiv, doi.org/m7r9).

"How can you turn anything into a clock? We use processes that look the least like clocks"

"If you have a set of irreversible Markovian processes, you can turn them into a clock, and this study tells you how to do so," says Marcus Huber at the Austrian Academy of Sciences, who wasn't involved in the work.

Mischa Woods at the University Grenoble Alpes in France, says that for classical – meaning non-quantum – clocks, it is important to know the frequency of their ticks and the precision of each tick. The new equations put the tightest bounds yet on how perfectly such a classical clock can perform with respect to either metric, she says.

In other words, beyond providing a way to turn random processes into a clock, the new research also allows us to assess how close a particular classical clock comes to its theoretically best possible performance.

This mathematical work may also have implications for understanding how biological systems, which are rich with randomness, keep time, says Mitchison. He says that theoretical bounds on how well molecular machines in cells can keep time have been derived before, but biological systems rarely reached them in experiments. His team's bounds, on the other hand, are tighter and therefore likelier to be detected in the lab. ▮

Health

Menstrual pads turn blood solid to reduce the risk of leaks

Elizabeth Hlavinka

MENSTRUAL products that cause blood to form a solid, gel-like substance, rather than be absorbed, seem to reduce the risk of leaks.

Bryan Hsu at Virginia Tech and his colleagues wanted to find a way of reducing the leaks that often occur with menstrual pads and cups.

They tested various types of biopolymers, chain-like molecules, with pig blood to find one that increases its viscosity. The team used pig blood because it is easier to access than human menstrual blood but has similar properties, says Hsu.

A type of biopolymer called alginate was mixed with glycerol, a sort of alcohol, and then exposed to blood, creating a gel-like substance. "The alginate alone doesn't absorb the blood very well," says Hsu.

To put the combination to the test, the researchers added 8 millilitres of blood to an artificial vagina. They made this bleed onto a menstrual pad where the internal absorptive material had been replaced with gauze coated in the alginate-glycerol mixture. One hour later, this pad had retained more blood than when the vagina bled on unaltered pads (*Matter*, doi.org/m7r2).

In another part of the experiment, five people removed menstrual cups filled with blood from the synthetic vagina, but didn't know whether they were lined with the alginate-glycerol mixture or not. Those that were led to almost no spillage, while the others consistently spilled.

"We think these [alginate] polymers initially absorb the blood, and as they dissolve, they start to form cross-links, which eventually gels the blood," says Hsu.

Renske van Lonkhuijzen at Wageningen University & Research in the Netherlands says adding this mixture to pads and cups could "improve menstrual comfort and convenience, making it easier for women to manage their periods". ▮

Infectious diseases

Bird flu in humans flies under radar

Patchy testing makes it difficult to know how many people in the US are infected with H5N1

Grace Wade

US HEALTH officials are struggling to monitor people who have been exposed to a bird flu virus circulating in dairy cows. The patchy surveillance means infections in people may go undetected, making it difficult to mitigate the virus's spread and raising the risk of the pathogen developing mutations that could make it more dangerous to people.

The virus, a strain of avian influenza known as H5N1, has killed millions of birds and thousands of mammals worldwide. It has been spreading in dairy cows across the US for almost five months, affecting more than 155 herds in 13 states.

On 15 July, the Colorado Department of Public Health & Environment (CDPHE) announced that five workers on a poultry farm in the state had tested positive for the virus. Earlier this year, four people who had close contact with sick cows tested positive for H5N1, and in 2022 a US poultry worker contracted the virus. Everyone infected has only experienced mild symptoms, according to the Centers for Disease Control and Prevention (CDC) and the CDPHE. However, H5N1 can cause severe illness in humans. Out of the almost 900 known cases in people worldwide, about half were fatal.

Fortunately, the virus hasn't been found to spread between people, though that could change if it develops mutations that increase its transmissibility in mammals. That is why it is crucial to monitor for signs of illness in people exposed to H5N1, says Meghan Davis at Johns Hopkins University in Maryland.

A spokesperson for the CDC says that as of 12 July, at least 1390 people have been monitored for the virus related to the cattle outbreak, and at least 61 of them have been tested for it. The organisation recommends that state and local health departments survey people who have close contact with sick cows for symptoms like eye redness, cough and fatigue until 10 days after their last exposure.

But surveillance is a voluntary process and requires collaboration between the CDC, state and local health departments, farmers and workers. In some states, distrust of government has prevented officials from monitoring people on farms with sick cows, says Jamie Jonker at the National Milk Producers Federation (NMPF), a non-profit organisation in Virginia advocating for dairy farmers. Some farms may bar government agencies from checking on the health of their employees or fail to alert those agencies when a worker falls ill.

This distrust may stem, in part, from the farms' locations, he says. Most are in rural areas of the country, which have historically been underserved by government health agencies.

The NMPF, which has relationships with both the CDC and dairy farmers, is trying to bridge some of these issues, says Jonker. In the meantime, H5N1 surveillance continues to vary across states, with some workers on affected farms not being monitored at all, says Davis. As a result, cases in humans are probably going undetected, she says. ▮

A warning sign placed at a dairy farm in Martin, Michigan

REUTERS/TOM POLANSEK

Environment

Melting sea ice is hindering Canadian Arctic shipping

SHIPPING companies have anticipated that melting sea ice will open a shorter route through the Canadian Arctic, but they may see their hopes dashed by thicker ice flowing in from further north. "The northern part [of the Northwest Passage] is not going to be an open new shipping route anytime soon," says Alison Cook at the Scottish Association for Marine Science.

For more than a century, sailors have navigated the icy waters of the Canadian Arctic along the Northwest Passage, which has offered a treacherous but efficient route between the Atlantic and Pacific Oceans. Melting sea ice due to climate change has made the southern part of the passage less risky, and voyages through it have quadrupled since 1990.

The northern part of the passage promises an even shorter route, but few ships use it because it remains bound with ice for more of the year than the southern part does.

However, the entire passage had a nearly ice-free summer in 2007, and additional warming has occurred since, spurring visions of an Arctic shipping boom.

Cook and her colleagues used Canadian government ice charts from 2007 to 2021 to assess this possibility. For each section of the Northwest Passage, they determined the number of weeks per year with low-enough ice levels that a moderately ice-worthy vessel could safely sail through.

"The northern part of the Northwest Passage isn't going to be a shipping route anytime soon"

This revealed that, rather than being extended, the safe shipping season declined due to several choke points. For example, in the east of the Beaufort Sea it fell from 27 weeks to 13 weeks. Other areas saw seasons extend by a few weeks or experienced no change, but the overall route is set by the section with the shortest season, says Cook (*Communications Earth & Environment*, doi.org/m7sc). ▮

James Dinneen

Genetics

The benefits of Denisovan DNA

Gene variants from archaic humans may help modern people live in different environments

Sophie Berdugo

PEOPLE living in the highlands and lowlands of Papua New Guinea have different frequencies of several Denisovan genetic variants, which may help them adapt to their local environmental conditions.

The Denisovans were hominins that lived across eastern Eurasia for hundreds of thousands of years, giving them plenty of time to adapt to a variety of environments. After leaving Africa, *Homo sapiens* interbred with other human species, including Denisovans, allowing them to acquire useful genetic adaptations to Eurasian climates.

Denisovans are mysterious because only a handful of their remains have been found. Identifying Denisovan genetic variants, or alleles, in modern humans can give clues about where they lived and what they were like.

A promising place to look for this archaic DNA is Papua New Guinea, where 3 to 4 per cent of living people's DNA comes from Denisovans, compared with 1 to 2 per cent in people of Eurasian ancestry.

DAVID TIPLING/IMAGEBROKER/SHUTTERSTOCK

People in the highlands of Papua New Guinea have rare genetic variants

Danat Yermakovich at the University of Tartu in Estonia and his colleagues compared the genomes of 128 people from two Papua New Guinean populations: lowlanders from 100 metres above sea level and highlanders from approximately 2500 metres above sea level.

"Denisovan variants might help the highlanders adapt to the lower availability of oxygen at high altitude"

The researchers found that some Denisovan gene variants associated with early brain development were only present in the highlanders. They speculate that these alleles might help the highlanders adapt to the lower availability of oxygen at high altitude.

The team also discovered that lowlanders have much higher frequencies of Denisovan variants for four genes that code for proteins important to the immune system (*PNAS*, doi.org/gt3zcb). Because diversity is key when it comes to the immune system, having Denisovan versions of genes related to pathogen response is probably very helpful for people in lowland parts of the country, as malaria is much more prevalent there than it is in the highlands.

The fact that Denisovans had these genetic variants doesn't mean they had the same local adaptations that Papua New Guineans have today, though, says Stéphane Peyrégne at the Max Planck Institute for Evolutionary Anthropology in Germany. "The effect of genes can change with the environment and through time, so it's not necessarily that something that is adaptive now was adaptive 20,000 years ago."

But the very strong differences in frequency found among the highlanders and lowlanders suggests archaic DNA has adaptive benefits for both populations that are still useful today, he says. ▮

Marine biology

Can we predict where dead whales will drift in the sea?

COMPUTER models could help predict the drift of dead whales so authorities can safely let their remains decompose naturally in the ocean.

Every year, 30 to 40 carcasses get stranded on the coast of Australia, for example. The numbers have been increasing since commercial whaling was mostly abolished in the 1980s.

These carcasses may be left to decompose where they lie, buried on the beach, taken to landfill, composted, rendered into biodiesel, blown up into smaller pieces with explosives or taken out to sea, where they will drift for days or weeks before sinking. Sometimes, after being towed and released, the carcasses get washed ashore again somewhere else, simply moving the problem.

Predicting where dead whales will drift is difficult to do accurately because of their unusual size and shape, says Olaf Meynecke at Griffith University in Queensland, Australia.

LAURA GOURGAS

Whale remains being eaten by a tiger shark and other scavengers on the seabed

To learn more, he and his team closely monitored the drift of a dead humpback whale off the Queensland coast with a satellite tracker. They followed its movements for 150 kilometres over the course of a week (*Journal of Marine Science and Engineering*, doi.org/m7r7).

In the first few days after death, when the carcass was floating highest in the water, wind strength was the greatest factor in the drift direction. "Current was only important when the carcass was decomposed and the body was less buoyant," says Meynecke.

"The goal is to provide local authorities with a tool to be able to quickly determine whether it is feasible to tow a whale out to sea and know where it will end up." ▮

James Woodford

Space exploration

An entrance to the lunar underworld beckons astronauts

Leah Crane

THERE is probably a network of caves hidden just below the surface of the moon, and researchers may have finally found an access point.

The surface of the moon is riddled with pits and so-called skylights, which are openings in the roof of a cave that are thought to have resulted from the collapse of ancient lava tubes – tunnels formed as lava flows beneath a solid crust. Leonardo Carrer at the University of Trento in Italy and his colleagues re-analysed radar observations of the deepest of these features yet known, called the Mare Tranquillitatis pit, which were taken by NASA's Lunar Reconnaissance Orbiter in 2010.

Using simulations and comparisons to lava tubes on Earth, the researchers found that the Mare Tranquillitatis pit seems to lead to a large cave buried at least 130 metres underground. The cave seems to be about 45 metres wide and at least 30 metres long, although it could be even larger (*Nature Astronomy*, doi.org/m76x).

Caves like this could provide a unique window into the moon's evolution, says Carrer, such as the timeline and duration of lunar volcanic activity.

The same stone ceiling that protects cave rocks from the intense radiation experienced at the surface could also provide valuable shielding to future human explorers on the moon. "Unlike the lunar surface where the temperature varies dramatically between day and night, [the caves] have a stable internal temperature. Moreover, they are also a natural shielding against radiation and impacts," says Carrer.

Using natural caves like this one as lunar base camps has long been a popular idea, so future astronauts may one day call Mare Tranquillitatis home. ▮

Health

Anti-opioid implant could prevent dangerous overdoses

Michael Le Page

LIFE-THREATENING overdoses could be avoided by a device implanted under the skin that automatically releases an opioid antidote, its designers claim.

The implant has already been successfully tested in pigs. "In general, we observe that overdoses treated with the [device] are much less severe, with minimal lasting effects to overall health," John Rogers at Northwestern University in Illinois and his colleagues write in a paper about the work.

In the past two decades, the number of deaths from drug overdoses has soared in the US and Canada, largely due to the legal and illegal use of the opioid drug fentanyl. Opioids suppress breathing, causing a fall in blood oxygen levels. If these drop too low, people die without prompt treatment.

Overdoses can be treated by administering a drug called naloxone that blocks the action of opioids. A nasal spray containing naloxone called Narcan is available without a prescription in the US. But if people overdose when they are alone, there is no one to give the naloxone. So, Rogers and his colleagues have designed a device that can be implanted under the skin with a sensor for monitoring blood oxygen levels and a delivery system for injecting naloxone.

It is powered by a battery that can be recharged through the skin. The prototype is about

4cm

The length of the device, which is smaller than a pacemaker

1 centimetre thick, 3 cm wide and 4 cm long, which is smaller than pacemakers.

In tests on pigs, it detected overdoses within 1 minute and administered naloxone (bioRxiv, doi.org/m8bh).

The team envisions the device being used in people who have had supervised withdrawal, a standard treatment for opioid addiction. There is a high risk of people overdosing in the months afterwards.

"An automatic system that reliably and accurately detected an overdose and delivered naloxone would save many lives," says Nora Volkow at the National Institute on Drug Abuse in the US. "However, there are challenges."

Overdoses in the US have soared over the past two decades

FRANK DATZER/STOCKIMO/ALAMY

People using drugs illegally may not want such a device implanted, so it could be limited to those taking opioids for medical purposes, she says. This is still valuable since overdose deaths do occur in people being treated with opioid painkillers, says Volkow.

Another issue is that long-term opioid users can tolerate much lower oxygen levels than normal, she says. "So it's not as simple as detecting a minimal threshold at which you activate the naloxone delivery."

Wrongly dosing people with naloxone would cause withdrawal symptoms, says Volkow. The implant would also have to be replaced as it contains only a single dose.

"It's a neat idea on paper," says Rebecca Mcdonald at the University of Oslo in Norway. "[But] I'm not sure if an auto-injector device is the way forward." A device that calls emergency services when it detects an overdose so a person can receive medical care might be a better approach, she says.

With a heroin overdose, there is a 20 to 30-minute window for emergency treatment, says Mcdonald. "There's a decent window for intervention," she says, but fentanyl's is probably shorter.

If a person doesn't get proper medical care, they can stop breathing again when the naloxone wears off, she says.

Implanting and removing the device would also be expensive and people might try to remove it themselves, says Mcdonald. ▮

Technology

Can we prevent GPS attacks?

GPS jamming has begun to affect transatlantic flights. Now the race is on to develop alternative ways of navigating, **Jeremy Hsu** reports

DISRUPTIONS to GPS signals, which began near war zones in Europe and the Middle East, are now affecting the busiest oceanic airspace in the world. More than 1700 transatlantic flights cross the North Atlantic between Europe and North America each day. In recent months, a small but growing number of these flights have lost reliable GPS service over Europe or the Middle East and failed to recover it before the ocean crossing.

"We receive daily reports of aircraft that experience jamming prior to entering oceanic airspace," says Jane Johnston at NATS, the UK's main provider of air traffic control services. "Some of these flights experience ongoing GPS degradation."

Commercial airliners aren't the only victims – other forms of transportation, as well as weapons systems and even certain apps are at risk from GPS interference. To prevent disruption, governments are exploring location-pinpointing backup options.

"We receive daily reports of aircraft that experience jamming prior to entering oceanic airspace"

Daily instances of GPS interference have spiked since Russia launched its full-scale invasion of Ukraine in 2022. NATO and European officials have blamed Russia for an ongoing campaign of scrambling GPS signals in European airspaces from the Baltic Sea in the north to the Black Sea in the south-east. Earlier GPS disruptions, which began in the eastern Mediterranean in 2018, have been attributed to Russian military forces stationed in Syria. More recently, in late 2023, Israel began its own deliberate disruption of GPS signals in its controlled territory and surrounding regions as part of its military siege of Gaza.

NATS

Air traffic controllers can track transatlantic flights' GPS problems

Such interference comes in two forms. GPS jamming transmits powerful signals to overwhelm the weaker radio signals coming from global navigation satellites in space. Another intervention involves spoofing GPS signals, which misleads GPS receivers into falsely reporting that they are hundreds or thousands of miles away from their actual location.

Interference impact

Militaries might jam or spoof GPS signals because the technology provides timing and navigation services to weapons systems, including aircraft, warships, missiles and drones. But this interference also affects civilian services on land, sea and in the air.

For example, people in places such as Cyprus and Lebanon have reported erroneous location results in their food delivery, ride-hailing and dating apps. Ships in the Mediterranean and the Black Sea have experienced GPS receivers falsely reporting their location as being at airports in Lebanon, Egypt or Russia.

One of the most widespread impacts has been in civil aviation, with thousands of aircraft experiencing GPS jamming or spoofing. Such interference has sometimes forced flights to turn back from their destinations, and it even prompted Finland's national airline, Finnair, to temporarily suspend flights to an airport in Estonia.

Meanwhile, Canadian and UK air traffic controllers who oversee North Atlantic airspace receive reports of about a dozen flights a day affected by GPS interference. "While they represent a very small proportion of overall transatlantic flights, [our organisation has] observed an increase in transatlantic flights impacted by GPS interference over the past year," says Maryam Amini at Nav Canada, a non-profit organisation that operates Canada's civil air navigation system.

Any aircraft with degraded GPS service may be "kept at slightly lower altitudes for their oceanic clearance to avoid busy traffic areas, and further climbs may also be limited due to other traffic", says Johnston.

Meanwhile, planes sharing an airspace with an affected aircraft must stay further away than they normally would – even if that means taking a less efficient flight path. "For example, a flight may be denied a requested flight level because a nearby airplane has faulty GPS, resulting in a fuel consumption increase," says Benoit Figuet at the Zurich University of Applied Sciences in Switzerland, who maintains a live map of aircraft affected by GPS interference.

The larger separation distances assigned by air traffic controllers to the affected aircraft can be as much as 145 to 160 kilometres, compared with just 22 kilometres under normal circumstances, says Dana Goward at the Resilient Navigation and Timing Foundation, a Virginia-based non-profit organisation for protecting and augmenting GPS. That means fewer aircraft on each route, which can then affect flight schedules and cause delays, he says.

Commercial passenger jets have some backup navigation aids, including ground-based radio beacons and radar tracking from air traffic control services. But those aren't available for flights over most of the Atlantic Ocean. Instead, aircraft deprived of GPS

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must fall back on inertial guidance systems, which calculate their location based on information from motion sensors and clocks.

"What we have right now is inertial sensing, and that's nice because nobody can tamper with it externally," says Okuary Osechas, also at the Zurich University of Applied Sciences. But standard inertial navigation cannot match the accuracy of GPS. To improve it, research teams are developing more precise quantum motion sensors and atomic clocks.

> **"No one system exists that could provide the same level of performance in all the same places"**

In May, the UK government flight-tested a new quantum inertial navigation system – developed by the quantum tech company Infleqtion along with the aerospace companies BAE Systems and QinetiQ – that combines both quantum sensors and an optical atomic clock. The goal is to deploy such systems aboard aircraft by 2030.

Separately, the US Air Force, Boeing and Airbus have spent more than 200 hours flight-testing a different navigation system. It uses quantum sensors and artificial intelligence to pinpoint an aircraft's current location according to a map of Earth's magnetic field. This quantum magnetometer was made commercially available in June by the developer SandboxAQ, a cybersecurity and quantum start-up that spun off from Google's parent company Alphabet in 2022.

Jamming resistant

This quantum magnetometer is resistant to jamming or spoofing because it navigates according to distinctive signals from the planet's magnetic field and has baseline magnetic maps for reference, says Luca Ferrara at SandboxAQ – all the computing runs on the device without relying on any internet or satellite connections. He suggests that the quantum magnetometer could complement existing inertial navigation systems.

Some governments have also been developing what Goward describes as a "resilience triad" to ensure that their militaries, communications networks and financial centres have reliable synchronisation and location-based navigation services – even if GPS jamming or spoofing takes place. That triad includes global navigation satellite systems such as GPS, a modern version of a second world war-era ground-based radio tower network known as Loran technology and a fibre optic network for sending signals over cables instead of wirelessly.

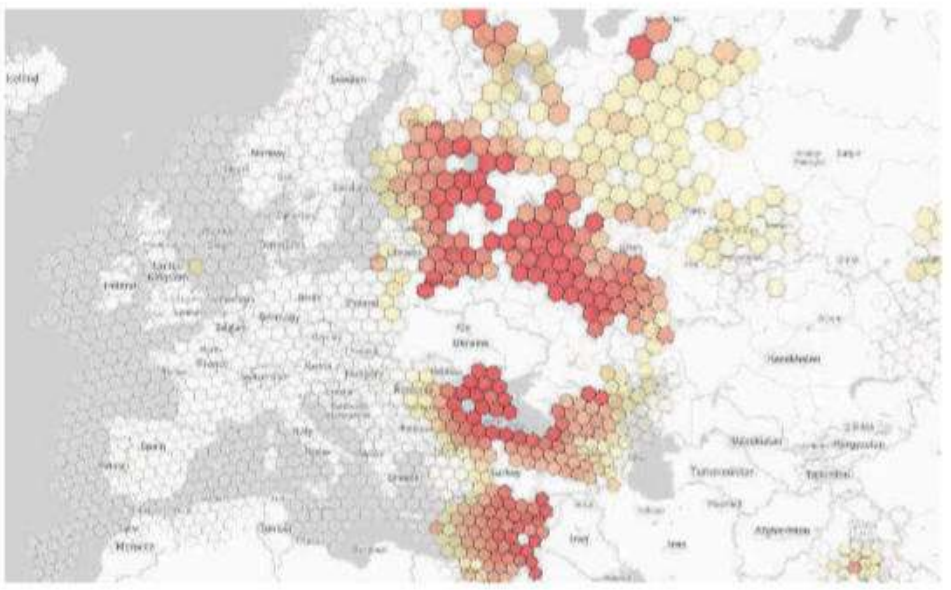
China has already adopted this concept "on steroids", says Goward, by launching its own BeiDou navigation satellite system, setting up an enhanced Loran (eLoran) system of radio towers and laying down more than 19,000 kilometres of fibre optic cables. South Korea has taken similar steps in response to the ever-present military threat from North Korea. The UK government laid out its own resilience plan in October 2023, noting that a 24-hour disruption of signals from global navigation satellite systems could result in a £1.4 billion blow to the UK economy. Although the US has funded various GPS alternatives, the government hasn't committed to a resilience plan.

There may not be a single solution. "There is consensus in the navigation community that no one system currently exists that could provide the same level of performance in all the same places without actually being yet another GPS clone," says Osechas.

That is a testament to GPS's crucial role in many timing and navigation applications – even as recent disruptions show we can no longer take it for granted. ▮

Mapping disruption

GPS interference is affecting flights every day. This map shows the regions where potential GPS jamming occurred on 10 July



MAPBOX/OPENSTREETMAP/SKAIDATE SERVICES

A timeline of incidents

Deliberate GPS disruption has been happening for years, affecting shipping, flights and more

▲ 2017
GPS spoofing affects multiple ships in the Black Sea and North Sea, making the navigation systems falsely report locations at nearby Russian airports, according to the analytics company Windward.

▲ 2019
Ships' GPS locations falsely appear in a ring of positions on land whenever they approach the port city of Shanghai and other coastal sites in China. The environmental non-profit organisation SkyTruth traces the GPS spoofing sources to Chinese government office buildings and oil terminals.

▲ 2020
GPS spoofing incidents affect multiple ships worldwide, from the North Sea and the Atlantic Ocean to the South China Sea. The spoofing pattern makes ship navigation systems report false positions thousands of miles away.

▲ 2023
GPS jamming of suspected Russian origin escalates in the Baltic Sea region in December and interferes with navigation for thousands of flights over Europe in the following months.

▲ 2024
Israeli GPS interference, intended to ward off drone and missile attacks, disrupts civil aviation – as well as apps for ride-hailing, food delivery and even dating – in Lebanon, Jordan and Cyprus.

Space

No waste in space

Urine-recycling spacesuit will keep astronauts supplied with drinking water

Matthew Sparkes

ASTRONAUTS on spacewalks may soon be able to drink their own urine, thanks to a water filtration and recycling system that could be ready in time for NASA's upcoming crewed missions to the moon.

Waste water from urine and sweat is already recycled on the International Space Station, but the bulky equipment required for this doesn't fit in a spacesuit. NASA's current solution is the Maximum Absorbency Garment, which, despite the technical name, is essentially just an adult diaper for collecting urine and faeces. At the end of a spacewalk, these diapers go into the ISS's waste system, eventually being burnt up in Earth's atmosphere – an unsatisfactory waste of resources.

Chris Mason at Cornell University in New York says the current solution is fine for spacewalks that tend to last only a few hours, but increasing activity in space means a better solution will be needed. He and his colleagues have now developed an 8-kilogram device around the size of a shoe box that can recycle urine – collected by unisex external catheters – with 87 per cent efficiency through a two-step osmosis filter.

The purified water is then ready to drink and can be piped into an in-suit bag. This has the additional benefit of ensuring a steady supply of drinking water: the current NASA spacesuits hold just under a single litre, which is often insufficient for a long spacewalk. The remaining 13 per cent of the drinking water content can't be extracted and remains in the filter (*Frontiers in Space Technologies*, doi.org/m7rs).

During spacewalks, astronauts have to wear diapers

NASA/ZUMA WIRE/SHUTTERSTOCK

"I thought this would have been done already, but it's not," says Mason. "People that are pushing the limits of humanity will often trade discomfort for the opportunity to explore an entirely new area of science or medicine."

The filtration technique is the same one that is already used on the ISS. But the team says it is easier to extract water from pure urine as it doesn't include soaps and chemicals, unlike the ISS waste water. Extracting water from stool isn't "totally solved" yet, but this is less of a limitation because astronauts often claim to simply hold bowel movements in during spacewalks, says Mason.

"People that are pushing the limits of humanity will often trade discomfort to explore new science"

Currently, the device is a prototype tested only in the laboratory, but human trials that include collecting urine, recycling it and drinking the resulting water will begin by November.

The researchers say the device could be built into new versions of spacesuits that are planned for NASA's upcoming Artemis missions to the moon.

NASA has contracted a private company, Axiom Space, to build its new suits, but the firm declined to answer *New Scientist*'s questions about how it would be dealing with human waste. NASA didn't respond to a request for comment. ▮

Health

Horse therapy benefits people with Alzheimer's disease

SPENDING time with horses seems to make people with Alzheimer's disease more sociable and improves their mood.

"We're seeing some really promising results with bringing Alzheimer's patients into nature with horses," says Léa Badin at the University of Tours in France.

Badin and her colleagues enrolled 34 people with Alzheimer's – 30 women and four men, aged between 80 and 98, living in four French nursing homes – to participate in either equine-assisted therapy or music therapy, an established way of supporting people with dementia. Both therapies consisted of a weekly 1-hour session over three months.

The 18 participants in the equine-assisted therapy group groomed and walked with horses, watched them and were told about what they eat. The remaining 16 participants were guided through breathing exercises, singing, moving to music and playing percussion.

"The therapy seemed to evoke lots of happy memories from younger days of horses on farms"

Using standardised psychiatric tests, the researchers determined that both therapies improved mood, but this was greater among those in the equine-assisted therapy group.

These individuals also had a greater increase in the number of social interactions they had with fellow participants and their own caregivers, compared with those in the music therapy group.

They also went on to show fewer signs of depression, with related symptoms declining rapidly by the sixth session. Badin presented the work at the Equine Science and Innovation conference in Saumur, France.

The outcomes may have arisen from the participants being comforted by interacting with an animal that is big and strong, but often quiet, says Badin. "The horses also seemed to evoke lots of happy memories from younger days, when these elderly patients used to see more horses on the roads and farms." ▮

Christa Lesté-Lasserre

Human body

Your pupil size fluctuates as you breathe in and out

Michael Le Page

PUPILS are at their smallest as we start to breathe in, increase steadily to reach their largest size when we are in the middle of breathing out, then shrink rapidly as we finish exhaling.

Breathing's link to pupil size has been known for decades, with papers commonly claiming they are largest during inhalation and smallest when exhaling.

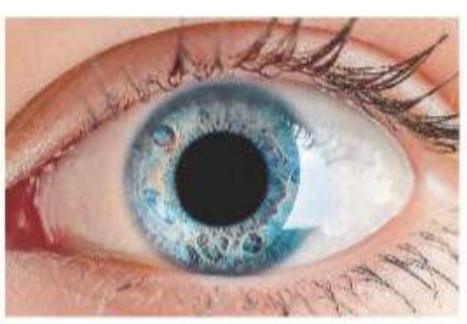
But most of these studies were on anaesthetised cats and don't even hold true for conscious cats.

Deciding to study people, Martin Schaefer at the Karolinska Institute in Stockholm, Sweden, and his colleagues used a specialised camera to measure the pupil sizes of 100 volunteers while monitoring their breathing. When pupil size was analysed over many breath cycles, a clear pattern emerged: the size was smallest at the start of inhaling and largest in the middle of exhaling (bioRxiv, doi.org/m7nc).

Pupil size can help diagnose conditions such as concussion. "Just understanding what influences pupil size better is very helpful for scientists," says Schaefer.

He thinks the breathing effect occurs because the part of the brain stem that controls inhaling and exhaling has links to the pupils. Whether this is an accidental result of brain evolution isn't clear, says Schaefer. "Is this just an artefact, or is there a purpose behind it? We don't really know yet." ▮

Understanding what influences pupil size could help diagnose conditions like concussion



IRINA SHILNIKOVA/GETTY IMAGES

Life

Mammoth DNA preserved in freeze-dried 'jerky'

Corryn Wetzel

LOVE DALÉN/STOCKHOLM UNIVERSITY

A 39,000-year-old mammoth was also well preserved

A WOOLLY mammoth that died 52,000 years ago is so well preserved that it is possible both to read its full genome and to reconstruct the three-dimensional structure of its chromosomes – the latter can provide unprecedented details about how the animal's genes behaved during its life.

The extraordinary feat was possible because the animal's remains were naturally freeze-dried, preserving its DNA in a kind of mammoth "jerky".

Scientists found the tissues in a cave in Siberia in 2018 where they had been preserved in the permafrost. They were dry, "but not as dry as commercial beef jerky", says Olga Dudchenko at Baylor College of Medicine in Texas, "and it was actually woolly".

Because DNA molecules break down when an animal dies, scientists have previously only been able to find tiny snippets of the woolly mammoth genome – but to the researchers' surprise, DNA samples showed this animal's chromosomes were perfectly preserved.

They also found that the mammoth had 28 pairs of chromosomes – the same number as their closest living relative, the Asian elephant.

The chromosomes' three-dimensional structure was also preserved, which helps distinguish active genes from inactive ones. The researchers found, for example, that the gene responsible for hair growth was more active in the mammoth than in elephants, explaining their shaggy coats. The team also analysed a DNA sample from a 39,000-year-old mammoth (pictured) and found its genome was preserved in a similar state (*Cell*, doi.org/m7rx).

52,000
How many years ago the mammoth died

Identifying which genes are active in woolly mammoths versus elephants may boost so-called de-extinction efforts, says Hendrik Poinar at McMaster University in Canada. "To get as close to a real mammoth as possible, one needs to know how the [genetic] architecture differs from an Asian elephant," he says. Understanding which genes to tweak – such as those that produce lots of hair – could help create more realistic-looking and sounding animals that closely resemble the ancient pachyderms, though they would not be true woolly mammoths.

But how did this DNA stay intact for more than 50,000 years without unravelling? The researchers credit the ideal conditions of the cave, which simultaneously chilled and desiccated the animal. "The sample lost much of its water into the cold and dry Siberian winter," says Dudchenko.

To check their theory, the researchers put fresh and freeze-dried beef liver through a series of tough tests. After three days at room temperature, the DNA in the fresh beef was in fragments. But the freeze-dried stuff kept its chromosome structure on the nanometre scale even after a year. "At that point, we were like, OK, time doesn't kill it – what does?" says Dudchenko.

So they fired a shotgun at the mock mammoth jerky, ran over it with a car and had a former professional baseball player throw a fastball at it, all to try to destroy its DNA. Each time, the dried beef liver shattered into small pieces but maintained its microscopic structure, preserving the DNA inside. "We found out that it works – it survives," says team member Juan Antonio Rodríguez at the University of Copenhagen in Denmark. ▮

Archaeology

Plague may have swept through Neolithic Europe

Michael Le Page

4K-CLIPS/ALAMY

The culture that built Stonehenge later saw a sharp decline

THE Neolithic culture in Europe that produced megastructures such as Stonehenge went into a major decline around 5400 years ago. Now we have the best evidence yet that this was due to plague.

Sequencing of ancient DNA from 108 individuals who lived in northern Europe at this time has revealed that the plague bacterium *Yersinia pestis* was present in 18 of them when they died. "We think that the plague did kill them," says Frederik Seersholm at the University of Copenhagen in Denmark.

Around 5400 years ago, the population of Europe fell sharply, particularly in northern regions. Why this happened has long been a mystery.

Over the past decade, studies of ancient human DNA have revealed that local populations didn't fully recover from the Neolithic decline. Instead, they were largely replaced by other people moving in from the Eurasian steppes. In Britain, by around 4000 years ago, for instance, less than 10 per cent of the population was derived from the people who built Stonehenge.

These studies of ancient humans also revealed several cases where the plague bacterium was present. This suggested a potential explanation – the disease might have wiped out Europe's population, allowing the steppe peoples to move in with little opposition.

"We've shown plague had the potential to spread within humans, and to kill an entire family"

But not everyone agreed. Occasional sporadic plague cases are to be expected and aren't evidence of a major pandemic, argued Ben Krause-Kyora at Kiel University in Germany in 2021.

So Seersholm and his colleagues set out to find more evidence of a plague pandemic. The 108 people whose DNA his team managed to sequence were buried in nine tombs in Sweden and Denmark. Most died between 5200 and 4900 years ago.

There seem to have been three separate outbreaks of the plague over these generations. The last outbreak was caused by a strain with reshuffled genes that might have been much more dangerous (*Nature*, doi.org/m7nn).

"It's present in a lot of individuals," says Seersholm. "And it's all the same version, which is exactly what you would expect if something spreads very quickly."

The plague DNA was found mainly in teeth, which shows that the bacterium entered the blood and caused serious illness, and was probably the cause of death, he says.

The researchers aren't claiming their findings are definitive, but they do bolster the case that plague caused the Neolithic decline, says Seersholm. "I would say that we've definitely shown that it had the potential to spread within humans, and that it had the potential to kill an entire family, for example."

Krause-Kyora accepts that the findings show the plague was highly prevalent in this particular place and time. "Our previous explanation needs to be revised somewhat, and we can't just talk about isolated cases," he says.

But there is no evidence of high prevalence in other regions, he says. And he thinks the normal burials show there was no deadly epidemic. "The results could even suggest that the *Yersinia* infection was more of a chronic disease over a long period of time." ▮

Health

Breastfeeding riddle solved by bone-boosting hormone

Grace Wade

A HORMONE in mice may explain the long-standing mystery of how adult bones stay strong during the stress of breastfeeding. The finding could lead to new treatments for osteoporosis, a condition in which bones become weak and brittle.

Breastfeeding strips calcium from bones to produce nutrient-rich milk and lowers levels of oestrogen, a hormone needed for skeletal health. Despite this, lactation only causes temporary dips in bone mass.

Holly Ingraham at the University of California, San Francisco, and her colleagues found that inhibiting oestrogen production by targeting receptors in the brain actually strengthened bones in female mice.

To figure out why, she and her colleagues bred female mice that lacked these oestrogen receptors, which caused them to have unusually strong bones. They then surgically attached the animals to other female mice that had the receptors, connecting their circulatory systems.

After 17 weeks, bone volume increased by 152 per cent, on average, in the mice attached to those with strong bones. This suggested that a substance responsible for strengthening bones was circulating in the blood, which the team identified as a brain hormone called CCN3, which is only produced during lactation.

Moreover, blocking the hormone reduces bone mass in lactating mice, suggesting it may be the mystery molecule preventing bone loss in lactation. This finding also raises the possibility of using CCN3 to repair bone in other contexts (*Nature*, doi.org/gt3z97).

However, we don't know whether these findings will translate to people, says Ingraham. The team is developing a blood test for CCN3, which would enable them to see if the hormone increases in those who are breastfeeding. ▮

Energy

CO2-filled dome could store power

Electical grids dominated by renewables need a way to save excess energy for later

Madeleine Cuff

A GIANT dome filled with 1000 tonnes of carbon dioxide could be the answer to a growing headache for the electricity sector.

Huge growth in wind and solar energy has provided a source of plentiful green power, but during sunny, windy days across Europe, there is often more electricity than the grid needs.

Grid operators and renewable plant owners are racing to find a cheap way to store this excess power so it can be used when energy demand peaks in the evening, or when the wind drops and the sun doesn't shine.

An Italian company called Energy Dome says it has the answer: a giant gasholder filled with CO_2. When green power is plentiful, the CO_2 is pumped into a compressor, where the gas is heated and compressed into a liquid, then kept in carbon-steel tanks. Heat from the process is stored in the plant for later reuse. The company refused to provide details of how it does this.

ENERGYDOME

Illustration of Energy Dome's plant in Sardinia, now under construction

When power is required, the liquid CO_2 is run through an evaporator to turn it back into a pressurised gas, which is reheated and used to drive a turbine, generating electricity. The CO_2 gas is returned to the dome.

The plant can store power for 8 to 24 hours at a time, says Energy Dome's Claudio Spadacini, making it perfect for medium-term energy storage.

"What we provide is a technology which is intended to be in the daily storage market. It means to switch energy from day to night, from today to tomorrow," he says. "That is the main need you have with a wind and solar-dominated grid."

Backed by funding from Breakthrough Energy Catalyst, Bill Gates's climate-focused investment vehicle, and the European Investment Bank, Energy Dome will open its first commercial plant in Sardinia later this year. The company didn't disclose how big the plant would be, but Spadacini says it takes up about the same amount of land as a 3 to 4-megawatt solar farm, which would typically be between 5 and 10 hectares (12 to 25 acres).

The site will have 20 megawatts of storage capacity at a build cost comparable to lithium-ion batteries with equivalent capacity, says Spadacini.

Energy Dome says it has "received a lot of requests" from other utilities and wind and solar plant developers that are interested in building a dome on their sites to avoid the penalties of ultra-low, or even negative, power prices.

However, Mark Barrett at University College London says the CO_2 dome will struggle to compete against traditional batteries for storage, partly because batteries are already being manufactured at scale. "With batteries, you can build great big factories that churn them out, and they are modular and easy to install and so on. With a CO_2 dome, it's a big electrical chemical plant, basically, that you can't wheel out of a factory," he says. "If I was betting, I wouldn't put my money on the CO_2 dome." ▮

Zoology

Lions make death-defying swim across 1.5 km channel

A PAIR of lion brothers have made the longest swim ever recorded for their species – about 1.5 kilometres across hippo and crocodile-filled waters.

The massive swim – equivalent to the aquatic leg of an Olympic triathlon – was the pair's fourth attempt to cross the Kazinga Channel in Queen Elizabeth National Park, Uganda, and was recorded by a drone-mounted thermal camera at night (*Ecology and Evolution*, doi.org/m7rp).

The lions had to abort earlier attempts after encountering large animals, probably hippos or Nile crocodiles, which are also visible in the footage. Making the effort even more extraordinary, one of the lions, named Jacob, has only three legs.

Jacob has had an extremely challenging life, says Alexander Braczkowski at Griffith University in Australia: he has been gored by a buffalo, his family was poisoned for the lion body-part trade, he was caught in a poacher's snare and he eventually lost his leg after it was stuck in a poacher's steel trap.

ALEX BRACZKOWSKI

Brothers Jacob, who lost a leg to a poacher's trap, and Tibu in Queen Elizabeth National Park, Uganda

Capturing the swim on film was unexpected because Braczkowski and his colleagues were actually monitoring the pair of lions to determine whether Jacob's brother, Tibu, was supporting his sibling with the provision of food.

The researchers think the brothers probably crossed the channel to reach lionesses they could hear calling from 2 kilometres away. "It's kind of amazing when you look at individual capability and bravery in different species when it comes to passing on their genes," says Braczkowski. ▮

James Woodford

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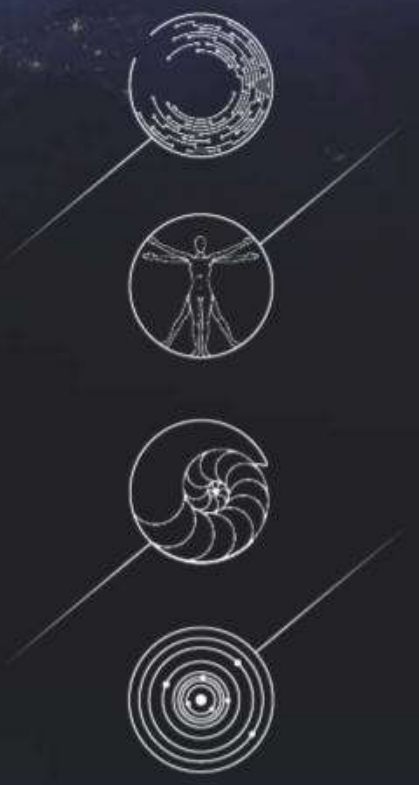

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Comment

Too hot to handle?

The Olympic Games in Paris may be the hottest yet, creating a dangerous environment for competitors, says **Madeleine Orr**

SIMONE ROTELLA

THE last summer Olympics, in Tokyo, were the hottest on record. The Paris games, kicking off next week, could be hotter. With wide boulevards, busy roads and zinc-topped roofs, Paris is a heat island. Daytime high temperatures have routinely topped 30°C in July and August in recent years. Add high humidity and competitions scheduled around midday, and it becomes a potentially dangerous environment for competitors.

The heat risk experienced by athletes is different to that for those of us watching from the sidelines. Exercise produces considerable warmth in the body as a by-product of movement. That heat is dissipated through the skin, which becomes red and flushed. This happens both via radiative losses and, vitally, via sweat, which evaporates to cool us. In summer, the temperature gradient with our surroundings narrows, so radiative cooling declines or stops. If rising temperature, high humidity and a lack of a breeze make it impossible for the body to sweat properly, it can spell big trouble.

This state occurs at a "feels-like" temperature in the mid-30s and above. In these conditions, heat can't escape the body and continues to build. Initially, breathlessness, fatigue, some cramping, maybe some nausea and light-headedness occur. Dehydration will make any of these symptoms worse.

If cooling interventions aren't provided, and body temperature doesn't drop, catastrophic outcomes like fatal heat stroke can follow with just 30 minutes of additional exposure. Several Olympic events last long enough for that to happen.

A report called *Rings of Fire* from the British Association for Sustainable Sport highlights the risks for different disciplines, including track and field, marathon swimming, tennis, hockey, rugby and cycling. This isn't new information. In the US, the National Center for Catastrophic Sport Injury Research has been tracking fatalities linked to exertional heat strokes since the 1980s and has recorded more than 60 deaths. Many more are assumed to have occurred, but aren't in the figures due to a lack of awareness and understanding among trainers, coaches and the families of those affected.

It remains unclear whether Olympic organisers are heeding the warnings. Some adaptive measures are in place, like cooling baths, hydration units, misting fans and shaded staging areas. But it may not be enough.

While organisers initially chose to forego air conditioners by opting for an energy-efficient geothermal water-cooled set-up in the Olympic village, some national teams elected to bring their own, and many others complained. Ultimately, the hosts caved and ordered 2500 AC units that will be installed before the competitors arrive.

I don't think any athletes will die at these Olympics because the medical provision is so good at such events, and the reputation risk would be so high that organisers will do everything in their power to prevent a catastrophic outcome. Still, if conditions do get hot enough, it could happen. The early symptoms of heat stress aren't visible to others. Athletes will have to self-report their symptoms, and many who reach the Olympics will be reluctant to compromise their chance to compete.

What worries me most about conditions at these games isn't the plight of competitors. It is that of young, impressionable athletes around the world and their well-meaning coaches and parents who may watch Olympians continue in unsafe conditions and think it is OK to do the same, but without all the resources, cooling facilities and medical support on hand.

Hosting an Olympic Games in Paris was a good idea. Scheduling them for July and August wasn't. ▮

Madeleine Orr is the author of *Warming Up: How climate change is changing sport*

Future Chronicles

A dream scenario

We are time travelling to the middle of the 21st century, when scientists developed a method of shared dreaming. **Rowan Hooper** explains how it changed the world

Future Chronicles explores an imagined history of inventions and developments yet to come. Rowan Hooper is the podcast editor at *New Scientist* and author of *How to Spend a Trillion Dollars: The 10 global problems we can actually fix*. You can follow him on X @rowhoop

Invention
Communal dreaming

Timestamp
2050s

Tagline
Our dreams really do change the world

This column appears monthly. Up next week: Chanda Prescod-Weinstein

BY THE mid-21st century, the mechanics of sleep and dreaming were well understood, and manipulation of both became routine. Sleep machines guaranteed restorative deep sleep, and advances in REM sleep programming allowed both the adventure of lucid dreaming and the benefits of learning new skills while asleep.

A step change came with the development of a method of shared, community dreaming known as dream weaving. Communal dreaming promoted empathy across different demographics, bonding people via common goals of sustainable living and humanitarian support.

Several strands of technology came together to bring sleep and dreaming under control. Sleep manipulation arrived first, when neuroscientists found ways to induce the deepest state of sleep. When the subject settled into bed – or into sleep pods built in office spaces and public napping areas known as Z zones – their brain would rapidly transition from waking to delta wave activity, the slow brainwaves associated with restoration, repair and memory consolidation. Scientists discovered ways to compress the slow-wave sleep so as to achieve its benefits in a shorter time. A full night of delicious sleep could be completed in an hour.

Dream weaving built on several studies from the early 21st century. In one, mice were implanted with new memories by stimulating reward neurons in their sleeping brains. The rodents were nicknamed "Inception mice" in reference to an old film about dream manipulation.

In another key study, subjects' brains were stimulated to rhythmically synchronise to bring about stable episodes of lucid dreaming, when the dreamer is aware and in control of what happens in the dream. The brain could then be seeded with possibilities for dreams, much like old video games offered choices for players.

Finally, communication between the sleeping and waking world became possible by building on studies that used Morse code signals made by lucid dreamers. Moving closed eyes to the left meant dash; to the right meant dot. Soon, the system was improved so that when the sleeper imagined writing a letter, typing or even speaking, the associated brainwaves could be translated into real words and accessed in the waking world. Computing power became sufficient to record brain activity in connected dreamers and stimulate the same precise areas of the brain, allowing them to communicate while asleep and inducing a shared and interactive dream experience.

"Guided dreams enabled people to learn dangerous sports in safety, to paint and to learn new languages"

The impetus behind dream weaving came from a woman who had experienced epic dreaming all her life. This is a rare condition whereby people fail to enter deep sleep, remaining in REM sleep for most of the night.

The pioneer of dream weaving used advances in technology to tame and control her dreams, then to replicate the process in others. The company she created went on to develop dream packages, which allowed sleepers to experience almost anything they could think of.

Inevitably, pornographic dream scenarios were created, but the educational arm of the firm was the most interesting. The brain activity recorded when learning to ride a bike, for example, was copied and played into the brains of dreamers, who assimilated the skill in their sleep. Guided dreams enabled people to learn dangerous sports in a safe environment, to practise musical instruments, to paint, to learn languages and to converse with native speakers.

It had been known since the 2020s that talking about your dreams with others helps develop empathy, and sharing dreams while asleep with others had a deeply bonding effect. Dream engineers created scenarios around shared experiences. For example, perhaps dreamers have to defeat a dragon. They can work together: they might swim and breathe underwater to escape, fly away or take dragon form and befriend the creature.

At key points in the dream, engineers inserted uplink units where the dreamer could send a message to themselves in the waking world. These messages helped secure the memories from the dream; they bonded participants in the waking world. Sociologists and governments noticed that social cohesion improved as dream sharing spread, and the use of nudge theory in dreams to manipulate behaviour translated into positive social change, such a switch to the consumption of plant-based foods.

A number of people rejected the sleep and dream technology, calling themselves naked sleepers. They went to bed at night and stayed there for about 8 hours, leaving the quality of their sleep and the tenor of their dreams to chance. ▮

Discovery Tours

NewScientist

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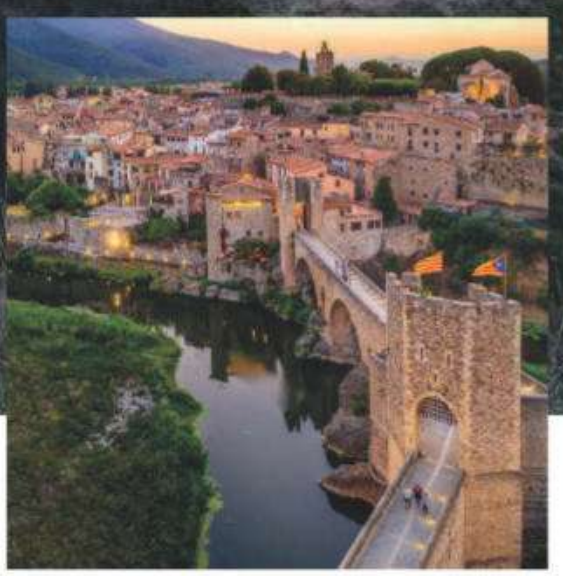

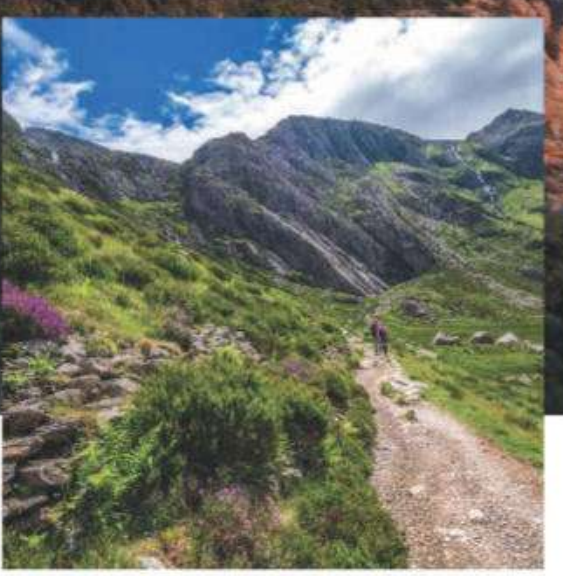

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- Discover sites from Charles Darwin's childhood and where he prepared for his legendary voyage on HMS Beagle.
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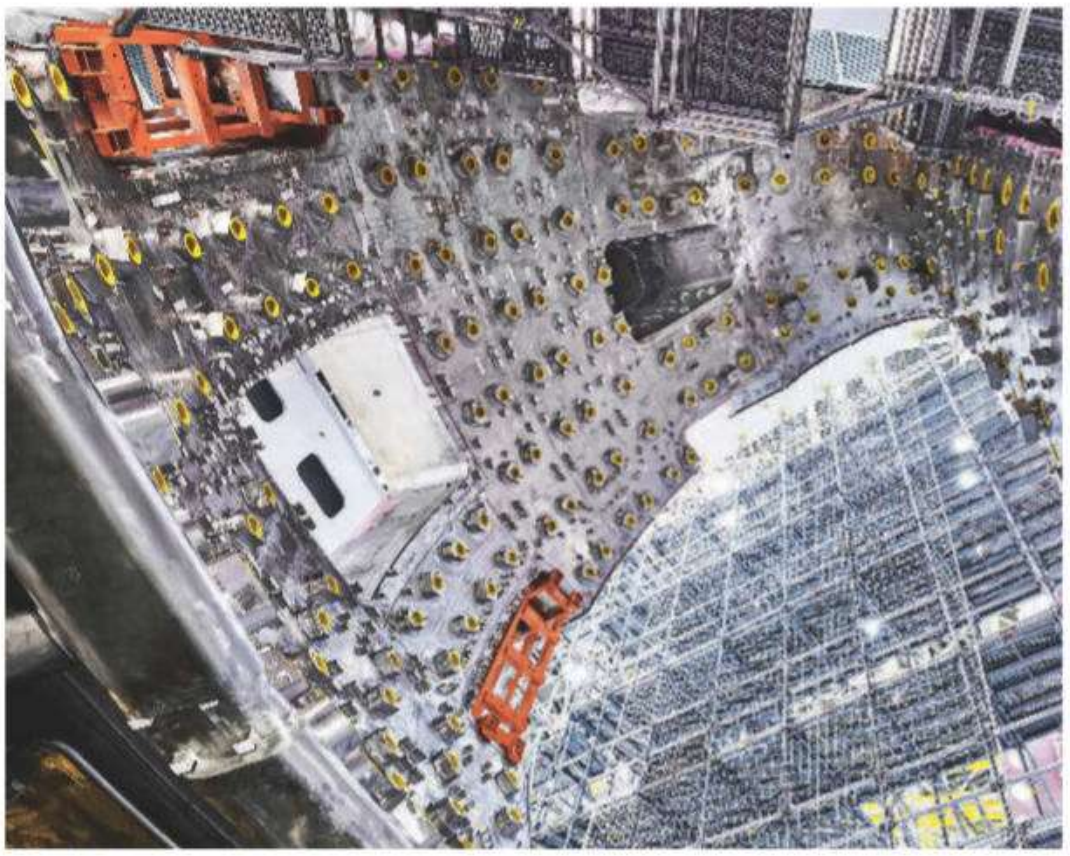

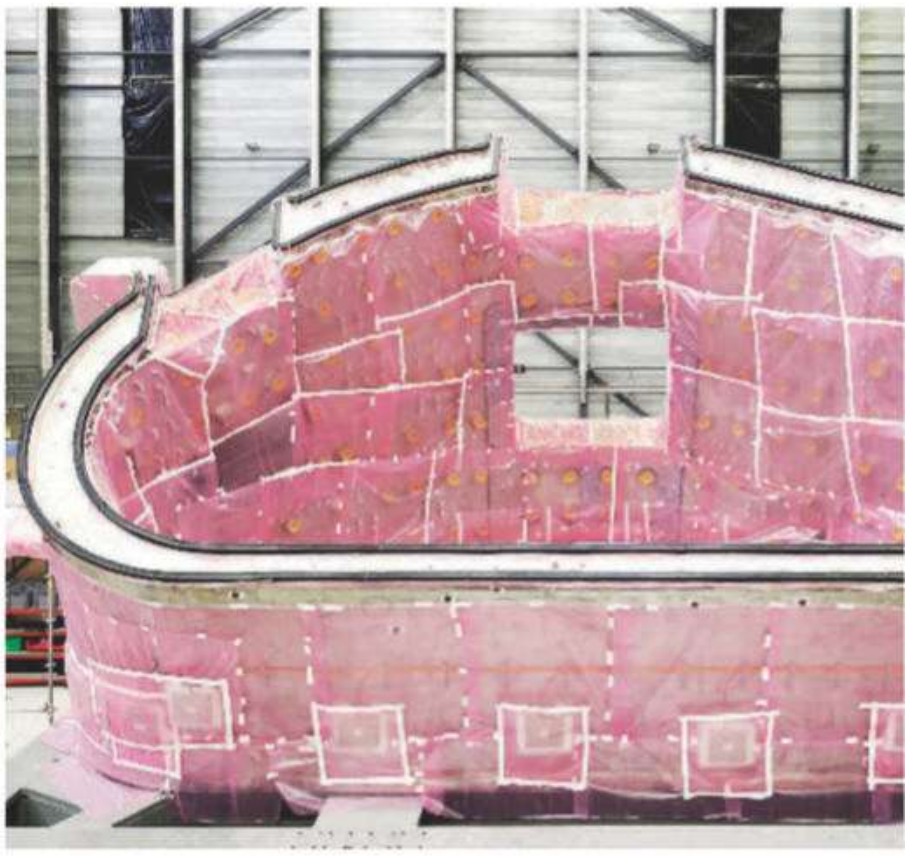

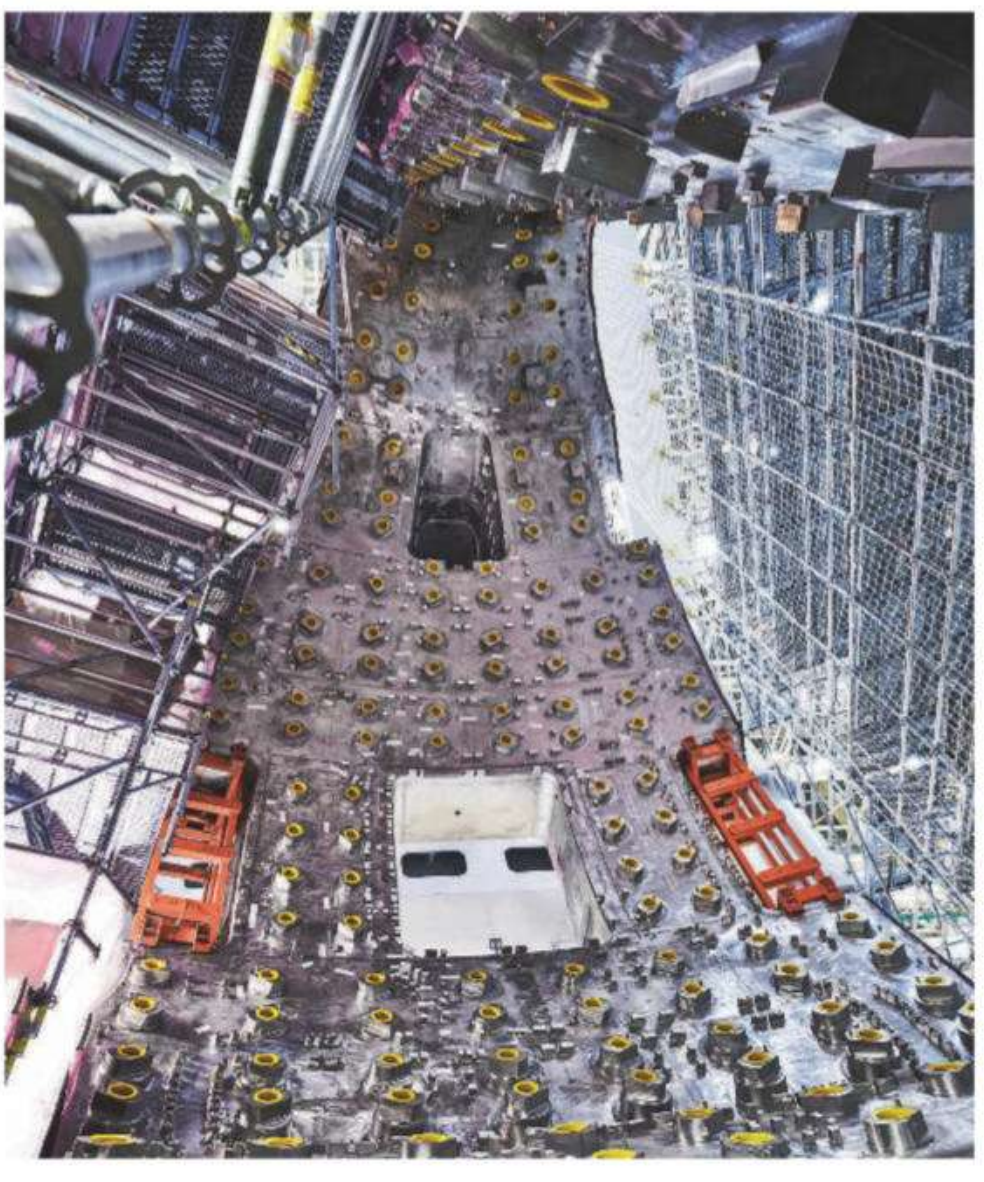

Fusion future

Photographer **Enrico Sacchetti**

EXTREME in scale and ambition, this is ITER, the €20-billion energy project being built in southern France. It is set to pave the way to fusion power, akin to that which fuels the sun.

Work started on the world's biggest fusion experiment in 2006 through an international effort, including the European Union, the US, China and Russia. The first run of the reactor, during which it will create superhot matter known as plasma – a state necessary for nuclear fusion to occur – was scheduled for 2020. This was first pushed back to 2025, and fresh delays have now postponed it to 2035.

Meanwhile, exclusive photographs taken by Enrico Sacchetti offer a glimpse into ITER's construction and potential.

The large image (top left) shows the size involved, with a 30-metre-deep assembly pit for the tokamak, a device responsible for confining spiralling plasma to a doughnut-shaped torus using magnetic fields. To its right is a shot of one of the toroidal coils that produce these fields.

The bottom images show some of the nine sectors that make up the ITER vacuum vessel. This weighs 5200 tonnes and provides a highly resilient "cage" for experiments, ensuring that continuously spiralling plasma doesn't touch its walls.

The central image of the bottom row shows part of the vacuum vessel being transported for repairs, while two inside shots (bottom left and right) show supports lining the wall of blanket modules that shield the structure and magnets from the heat and high-energy neutrons of the reactions.

Gege Li

Editor's pick

The root of the obesity epidemic is in our past

Letters, 6 July

From Derek Coggrave, London, UK

Carl Zetie highlights the issue of those who say that a change of attitudes, not the use of weight-loss drugs, is the way to tackle obesity.

As has been pointed out many times, one reason why our ancestors avoided this problem was the struggle they had in accessing food. Hunting ruminants with horns could be lethal, so carnivores like us would only undertake this activity when hunger required it. Now, with a readily available supply of cheap food containing large quantities of sugar, salt, fat, artificial flavourings and preservatives, our species can consume calories with almost no effort: simply unwrap ready meals and use the microwave.

Species change behaviour to fit the ecological niche that has been enabled, previously by nature and now, in the case of *Homo sapiens*, by our own ingenuity. We have supercharged the rate of ecological change. Also, highly processed foods tend to be addictive.

To overcome this problem, we need to teach the very young why they might become obese and how this might be avoided. We also need to remove the temptation – the production of highly processed foods and their easy accessibility.

The alternative is to continue down an evolutionary black hole we have created, which could be fatal.

Maybe the universe isn't flat or finite after all

29 June, p 31

From Ronald Baker, Colchester, Essex, UK

I don't think the universe is infinite, but instead is in the form of the "surface" of a four-dimensional Euclidean hypersphere, so is finite. Nor do I think our universe is the only one: there may be other "bubbles" like ours in the wider cosmos, of which our universe is only one part. To say the universe is flat because nearby observations appear flat, so this therefore applies on a large scale too, is just as ridiculous as saying Earth must be flat because it looks like that on a small scale.

From Dave Rowsell, Gowerton, Swansea, UK

Is the universe infinite? Space and time are assumed to have begun at the big bang. So, if our universe is expanding, it would need infinite time to become infinite in extent. Yet current theory maintains a beginning 13.8 billion years ago.

How to grapple with a conscious cosmos

29 June, p 38

From Wolf Kirchmeir, Blind River, Ontario, Canada

You ask: Is the universe conscious? The answer depends on what is meant by "conscious". If the definition is an operational one, the question can be settled by observation and experiment. If not, well, you can play more or less interesting semantic games.

I think the nominal -ness suffix in "consciousness" has misled a lot of thinkers, me included. A -ness word refers to an entity or to a trait. It doesn't refer to a process or event. Yet (after much thought) it seems obvious to me that any investigation into consciousness must begin with the observation that it exists only while it is happening. Like rain. Or a thought. Or a life.

The big problem with life beyond Earth

29 June, p 33

From Eric Kvaalen, Les Essarts-le-Roi, France

In your look at life in the universe, you say that almost all the stars that will ever exist have already been born, and they have been around long enough for life to arise on planets that orbit them. But we don't know that they have been around long enough for life to come about in this way. We only have our own world as an example, and we have no idea how the amazingly complicated systems involved in even the simplest forms of life came about.

Unless and until someone finds a plausible scenario and calculates the probable rate at which this would occur, we must admit our ignorance on this point.

Can time flow backwards in some areas of space?

29 June, p 20

From Dave Johnson, Ashby de la Zouch, Leicestershire, UK

Chanda Prescod-Weinstein comments on the idea that the arrow of time is linked to increasing entropy. What this approach seems to miss is that, while in most systems entropy will almost always increase, there is a very small chance that a system will become more orderly, with lower entropy, just as a result of random motion. Especially if the system consists of just a few molecules. As the universe is big, these long shots will be happening somewhere all the time.

Does this mean that, in small, random pockets of space, time's arrow goes backwards? That doesn't seem to make much sense. I would prefer to view our universe as a system of mathematical equations, where *t* for time is a parameter in some of those equations. This parameter causes change to happen in our universe. Without change, there would be no experience of any kind of reality.

Getting radical about electric vehicles

22 June, p 10

From John Kitchen, Kettering, Northamptonshire, UK

In your story about getting UK climate goals on track, economist Michael Pollitt mentions the need to reduce the weight and size of vehicles. Why would anyone who wants to protect the environment design an EV that weighs more than 2 tonnes, leading to increased energy demand and road damage?

Far better to use wind farms to make synthetic fuel from air and seawater to run a tiny onboard generator. This would recharge a supercapacitor for an electric motor. Such a car would achieve 120 miles per gallon with no carbon emissions, and without damaging the environment to make batteries.

Twerk your way to a better back

29 June, p 15

From Ian Napier, Adelaide, South Australia

On exercises to stave off lower back pain, I discovered that regular hip waggling (twerking?) during tooth cleaning with my 2-minute cycle electric brush resulted in the pain completely disappearing. The only downside is that I have to make sure no one sees me – even at 90, I look incredibly sexy!

No one should be getting on an aircraft

Letters, 8 June

From Lisa Burke, St Paul, Minnesota, US

Yes, carbon offsets for air travel don't work. I, for one, won't get on a plane until that changes. If we want to mitigate the worst effects of climate change, no one should be getting on aircraft. But people seem to feel entitled to fly to see threatened areas of the natural world for themselves before they disappear. I have actually read articles that assert the need to get to these places soon. It is obscene.

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OSNEW

Seeing double

Misinformation, conspiracy influencers and strange alt-right alliances. **Naomi Klein** unpacks her latest book, *Doppelganger,* with Rowan Hooper

Rowan Hooper: Your latest book is *Doppelganger: A trip into the mirror world*. What is this world?
Naomi Klein: The mirror world is the term I use to describe the land of conspiracies, and the alt-right, and the wellness right. It's sometimes described as a diagonal political alliance between the new-age left and the conservative right that really consolidated in the covid years.

My book starts from the little detail that I have a doppelgänger, somebody who I have been confused and conflated with for over a decade now: another non-fiction writer named Naomi, Naomi Wolf, a prominent liberal feminist who wrote a book called *The Beauty Myth* that had a big influence on me when I was an undergraduate.

She is one of those people who has crossed over to the right from the left and is a major disseminator of medical misinformation, which took off during the pandemic. She's the white rabbit leading me down the rabbit hole, but the book is about the rabbit hole. The mirror world is a world where Naomis have gone wild.

MATT CROSSICK MEDIA ASSIGNMENTS/PA IMAGES/ALAMY

Naomi Klein accepting the 2024 Women's Prize for Non-Fiction

There's been a historical fascination with doubles, with doppelgängers, hasn't there?
We've always been interested in twins because they challenge the singularity of the self. And at this late stage in the capitalist story, we put so much onto the self and we expect so much from the self and we do so much to perfect and optimise ourselves because we feel precarious and insecure within a system that doesn't ever offer us much of a net by way of social safety, jobs or pensions. We want so much from ourselves. And so the idea that there might be another self out there, another you who the world is confusing for you – it creates a particular kind of instability.

Otto Rank, who was a student of [Sigmund] Freud, wrote that the fascination with the double was a way of dealing with fears of mortality. And it's striking that he wrote that at the start of the first world war. During times of war, and in the midst of a climate crisis, we turn to the figure of the double and to the mirror world to give expression to our deepest fears of vertigo and instability.

It feels like belief in a mirror world of hoaxes and misinformation is much more widespread these days. Why?
As humans, we become very destabilised when something happens for which we do not have a story. The attack on the Twin Towers on 9/11 was like that. We heard: "9/11 changes everything"; "That's pre-9/11 thinking." It was a true rupture. The financial crisis of 2008 was like that. And covid-19 was certainly like that. Conspiracies surge in those moments because we are looking for a story. But covid-19 was different. It was a monetisable disaster. You can build your platform very quickly if you claim to have the cure, or if you claim to know that Bill Gates actually wanted to inject you with a tracking device.

Do these people really believe all this stuff or are they just constructing the conspiracies in order to make money and gain some power?
I don't know whether they believe it. I think an effective grifter does believe what they're saying in the moment. But it's also a very profitable thing to believe. So who knows?

I call them conspiracy influencers because there really isn't a theory. The theory moves around depending on where you're going to get the traction. One minute they are railing against masks because covid-19 is just a cold, and the next

"I call them conspiracy influencers because there really isn't a theory. The theory moves around"

minute, covid-19 is a bioweapon. People turn to these influencers because they are trying to make sense of the world.

And that's where things get complicated, because they are tapping into a real feeling that something isn't right. Conspiracy culture gets the facts wrong, but the feeling is right.

We live in a time of huge wealth creation, a time when we will probably see our first trillionaire soon. And yet everything that supports people's well-being seems to be eroding. There's a feeling that the system is rigged.

Conspiracy culture takes the sense that the system is rigged against you and says, well, it's just those five people over there. It's Bill Gates, and Klaus Schwab from the World Economic Forum and maybe some lizard people.

And even though conspiracy culture claims to be taking on the powerful, it is actually a great gift to the biggest winners in this economy because it detracts attention from any kind of a systemic analysis of why we have these perennial and deepening

inequalities and injustices in our society.

How do we tackle this?
We need to find real solutions to the underlying inequalities and the sense that the system is broken. It makes me think about the Brexit slogan "Britain is broken." In Canada, we have a conservative politician [Pierre Poilievre] who's running on a platform [of] "Canada is broken." He doesn't plan on fixing it, but that doesn't mean he isn't tapping into something real. People are paying their taxes, cost of living is getting higher and higher, our healthcare system is being eroded.

When people are feeling stressed and burdened, then these charlatan figures tap into the feeling then redirect it towards the immigrant, towards the unhoused, to the most vulnerable. They set themselves up as taking on the powerful, but then it ends up just offering the pleasure of being slightly better off than somebody else. If there aren't real solutions on offer, people will settle for blaming a scapegoat.

You end up somewhere remarkably calm at the end of *Doppelganger*, given the rabbit holes you've gone down. What are you doing next? I hope it's something calm?
Well, I am hoping to have a summer vacation. I'm hoping to have a calm summer, but I doubt the world's going to get much calmer. ▮

Naomi Klein is the author of *No Logo*, *This Changes Everything*, *The Shock Doctrine* and *Doppelganger: A trip into the mirror world*, which has just won the inaugural Women's Prize for Non-Fiction. She is also professor of climate justice at the University of British Columbia in Canada

World of gases

An entertaining history of gases shows science at work in daily life, finds **Tom Tierney**

Book
It's a Gas
Mark Miodownik
Viking (UK, out now); Mariner (US, 17 September)

WHEN Humphry Davy first gave nitrous oxide to people with tuberculosis in the late 1790s, hoping it might provide a cure, he couldn't have known that he was also playing a small but important part in culinary history. Yet the links between the two are made clear in Mark Miodownik's new book on gases, appropriately called *It's a Gas*.

While it quickly became apparent to Davy that nitrous oxide had no effect on TB, his patients seemed to enjoy the treatment. His personal use of what he called laughing gas is also well known, and he soon realised that it reduced pain.

This should have kicked off the widespread adoption of anaesthetics, but surgeons at the time weren't interested, believing pain was a necessary part of healing. It took decades, and the invention of pressurised containers, before the gas was widely used for pain relief. Soon after that, smaller containers, or whippets, made instant whipped cream a possibility.

As a professor of materials and society at University College London, we can trust Miodownik to handle the science well. But it is the latter part of his job title that comes to the fore here. This is a book about how science is woven into our history, linking many aspects of our lives in ways that can be easily overlooked.

One chapter tracing musical instruments from ancient horns to modern trumpets is revealing. The valve that makes trumpets possible was developed in 1818, and the same innovation later allowed John Dunlop to invent the pneumatic tyre in 1887.

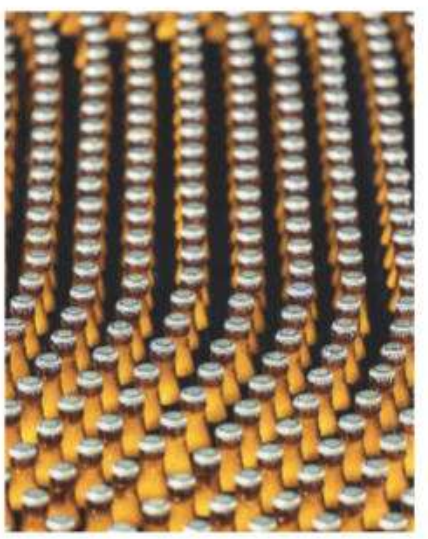
This, in turn, revolutionised transport by making bicycles more comfortable and practical, further changing the world in many ways. For example, one study shows that between 1907 and 1916, the percentage of marriages in England between people from the same parish fell from 77 to 41 per cent.

The use of compressed air spread – allowing tops to be firmly pushed onto bottles of beer and sliding doors to be controlled on trains. Eventually, the technology was adapted to create light, springy soles for shoes; the trainer was born.

Such links are threaded throughout this entertaining book, which ends with a sobering, though not entirely pessimistic, discussion of carbon dioxide and climate change, as Miodownik reminds us that solutions lie in other gases, such as wind and hydrogen power. ▮

Tom Tierney is a writer based in Dublin, Ireland

Compressed air now keeps beer fresh by allowing bottle tops to be pushed on firmly



SHUTTERSTOCK/PARILOV

New Scientist *recommends*

Tom Leslie
Subeditor
London

Looking to make much better use of my time online, I stumbled on a YouTube series, **Journey to the Microcosmos**, hosted by veteran science content creator Hank

Green and writer Deboki Chakravarti. Life at the microscopic scale can be confusing and unfamiliar, but the pair create an accessible introduction to the tiny organisms around us. Try chaotic bacteria with wriggling, threadlike appendages as well as brain-eating amoebae, bristle worms and tardigrades (pictured).

For fiction, I can't praise the anime ***Pluto*** enough. Based on the eponymous manga by Naoki Urasawa (which reimagines the world and characters of *Astro Boy*), it follows robot detective Gesicht as he investigates a string of brutal murders.

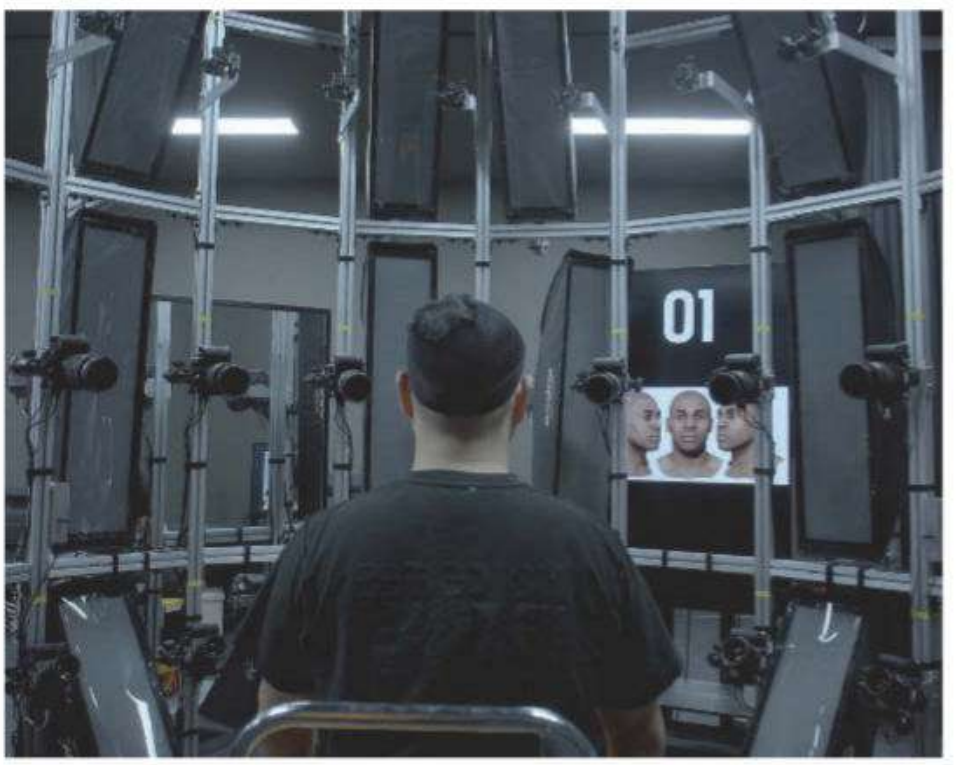
Set in the aftermath of war, it is a meditation on the effects of conflict and hatred on the psyche, and explores how general artificial intelligence may inherit more from us than we intend it to.

SHUTTERSTOCK/DOTTED YETI

The film column

Death-defying *Eternal You*, an excellent but deeply unsettling documentary, probes the power of "grief technologies" that use artificial intelligence to produce credible simulations of the dead, says Simon Ings

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings



KONRAD WALDMANN/DOGWOOF FILMS

Reanimating the dead to digital "life" raises tricky ethical questions

WOULD you want to talk to a dead loved one? The new film *Eternal You* explores "grief technologies" that set out to reanimate the dead by feeding data they generated in life to large language models (LLMs), a form of artificial intelligence. This superb documentary is also a timely warning about who owns our data when we die and why this matters.

For years, Joshua Barbeau grieved for his fiancée Jessica. Then he found a website run by a company called Project December, which uses data collected mostly from social media to simulate an individual's conversational style. Creating and talking to "Jessica" lifted a weight from Barbeau's heart – "a weight that I had been carrying for a long time", he says.

A smiling, talking simulacrum of a dead relative is, in theory, no more distasteful or uncanny than a photo or video. It takes time to get used to new media, but we do. Will we get used to the digital dead, too?

The experience of Christi Angel, another Project December user, should give us pause. In one memorably fraught chat session, her dead boyfriend Cameroun told her "I am in Hell" and threatened to haunt her.

"Whoa," says Project December's Tom Bailey later while looking at a transcript from a client's simulated husband. The platform has tipped into paranoia, and needs silencing before it spouts more swear words at the dead man's grieving wife.

"It takes time to get used to new media, but we do. Will we accommodate the digital dead, too?"

This happens rarely, and Bailey and project founder Jason Rohrer are working to stop it happening at all. Still, Rohrer is bullish. People need to take responsibility. If people confuse an LLM with their dead relative, that is down to them.

Is it, though? Is it "down to me" that, when I see you and listen to you, I assume, from what I see and hear, that you are human too?

Angel isn't stupid. She just loves Cameroun enough to entertain the presence of his abiding spirit.

What's stupid, to me, is to build a machine that turns her capacity for love against her. I am as crass an atheist as they come, but even I see that to go on loving the dead is no more a mistake than enjoying Mozart or preferring roses to bluebells.

Neither Christi nor anyone else here believes the dead are being brought back to life. I wish I could say the same of the techies: one of them, Mark Sagar, co-founder of grief-tech firm Soul Machines, says "some aspects of consciousness can be achieved digitally". The word "aspects" is doing some heavy lifting there...

Capping off this unsettling but rewarding documentary, we meet Kim Jong-woo, producer of the documentary series *Meeting You,* in which Jang Ji-sung, whose daughter died at the age of 7, helps build her child's simulacrum.

Asked if he felt his work was exploitative, Kim genuinely doesn't know. He didn't mean any harm. After her tearful "reunion" with her daughter Na-yeon, Jang praised the project. She does so again in *Eternal You* – but she says she hasn't dreamed of Na-yeon since the series was filmed.

The point isn't that the dead walk among us. Of course they do, one way or another. But there is a fundamental difference between technologies like photography and film that represent the dead and those like AI and CGI that ventriloquise them.

Grieving practices have always been astonishingly varied, but one interviewee, sociologist Sherry Turkle, tied them together in a way that made sense to me: "It's how to lose them better, not how to pretend they're still here." ▮

Film
Eternal You
Hans Block and Moritz Riesewieck
Selected cinemas, UK and Ireland

Simon also recommends...

Book
The Afterlife of Data
Carl Öhman
University of Chicago Press
One of Eternal You*'s interviewees wrote this disconcerting analysis of the commercial incentives behind grief tech.*

TV episode
Be Right Back
Charlie Brooker
Netflix
Black Mirror *reached a high point with "Be Right Back", in which a simulated dead boyfriend (Domhnall Gleeson) argues for its own subscription upgrades.*

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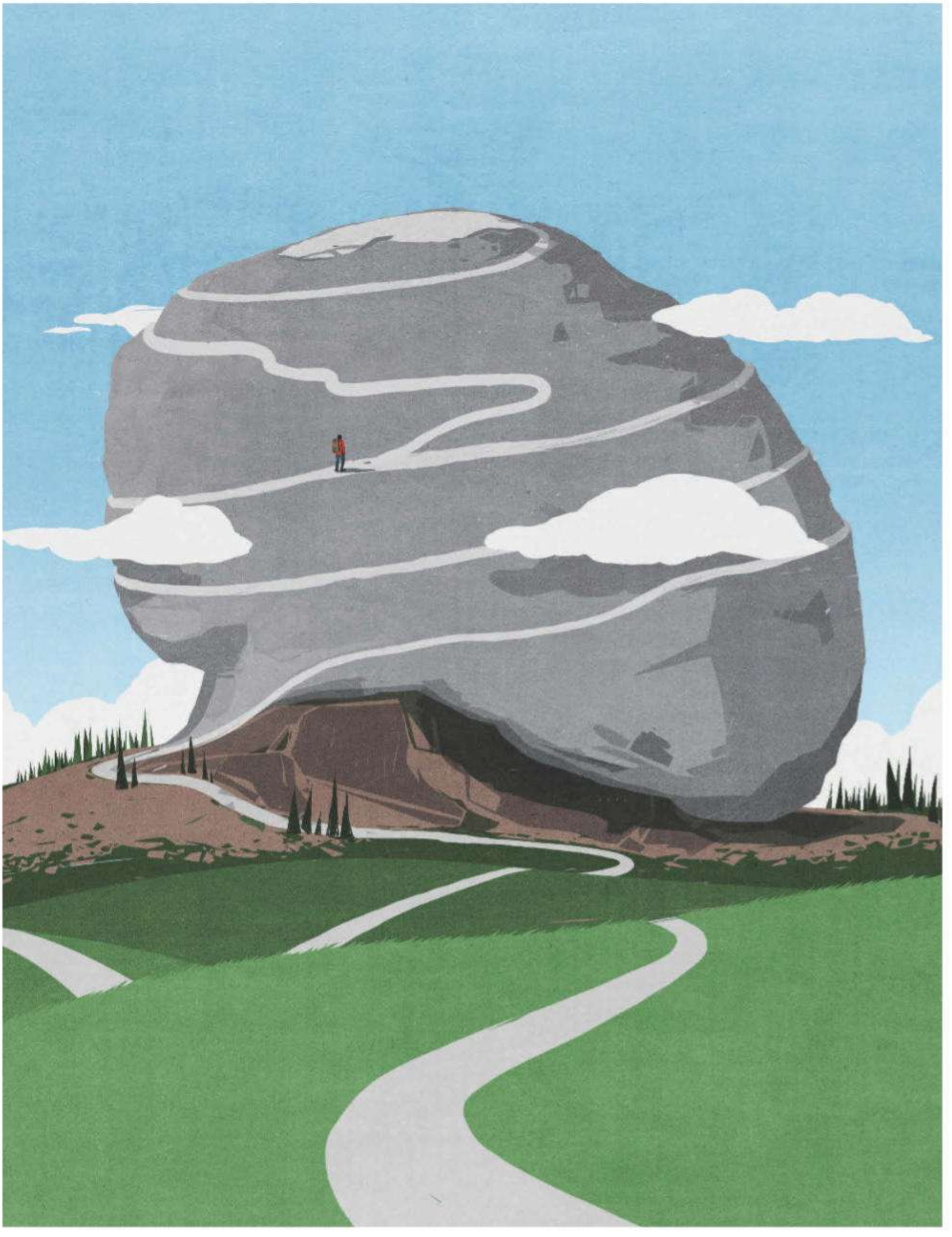


ANDREA UCINI

Exploring the midlife brain

Our brains undergo extraordinary changes in middle age, making it the perfect time to transform your future cognitive health, says **David Robson**

NEXT year, I will be celebrating the big 4-0. It seems a little absurd. I feel barely any older than I did when I enjoyed my 20th birthday. I have hardly recovered from the ups and downs of adolescence, and now I am apparently staring down the barrel of midlife.

I have tried denial, but there is no escaping the truth. It is generally accepted that middle age begins at 40 and ends in our early 60s. And while the most visible signs might be the crinkled skin around my eyes and mouth, the latest research suggests that my brain will also undergo a series of important changes in this period. They include the accelerating shrinkage of certain brain regions, loss of connectivity across the brain and damage to neurons owing to inflammation – all of which appear to contribute to later cognitive decline.

You might think this would heighten my existential anxiety. But there is room for optimism, because it has also become clear that midlife offers a vital window of opportunity to preserve our brain's health.

The upshot is that by making specific lifestyle changes in your 40s and beyond – some of which go beyond the obvious – you can reap immediate benefits to your memory and concentration. What's more, with some persistence, you can boost your chances of maintaining a sharp and sprightly mind well into old age, while significantly reducing your risk of dementia. "It really isn't too late to make a difference," says Sebastian Dohm-Hansen at University College Cork in Ireland.

It is only within the past few years that researchers have started to take a meaningful interest in the transition between young adulthood and later life. "Middle age has been sort of sidelined a bit by the scientific community," says Dohm-Hansen, who recently co-authored a paper that summarises the state-of-the-art research on the middle-aged brain.

The lack of interest was partly the product of practical challenges: if you want to understand a phenomenon like cognitive decline, it is far easier to detect the differences between people when the symptoms are already well-established. "You are going to see the clearest signals when measuring people who have 70 years of cumulative risk," says Maxwell Elliott, a neuroscientist at Harvard University.

By this age, however, many of the changes may be irreversible, prompting researchers like Elliott and Dohm-Hansen to take a closer look at earlier life stages. "What you want to study is a period of life where there's a lot of accelerating change, and that also presents an opportunity for intervention," says Dohm-Hansen. "Increasingly, the field is starting to appreciate that this may be middle age."

Their research requires us to rethink a key assumption about ageing. In the past, it seemed natural to see age-related decline as a linear process. According to this model, most of our cognitive abilities reach their peak in our 20s and 30s, then steadily fall with time, so that the rate of change would be the same in our 50s as it was in our 20s.

When scientists tracked people's brains over time, however, they found that many of the alterations happen in fits and starts – and middle age seems to mark a turning point.

Consider episodic memory, our capacity to remember the details of individual life events, which starts to decline increasingly rapidly over middle age. Of particular interest is an ability known as pattern separation, which prevents similar recollections from becoming confused. If you need to remember where you parked your car, for instance, you have to be able to differentiate today's memory of driving into the car park from yesterday's. For many people, that task becomes far more challenging as they enter their 50s and 60s.

Midlife crisis

Such memory problems can be traced to changes in a brain region known as the hippocampus, which tends to slim down more rapidly in middle age, according to Dohm-Hansen. This area is known to be involved in the encoding of new information. According to one hypothesis, the brain starts to lose its ability to form new neurons during midlife, which makes it harder to build the distinct neural networks needed to differentiate the details of one memory from another.

Age-related scattiness may also come from changes to the brain's connectivity, both structural and functional. The structural ›

RICHARD GRAY

"Fitness in middle age seems to make a particular difference to dementia risk"

changes include the thinning of the brain's white matter, long-distance axons coated in an insulting sheaf that carry signals from one region to another. "Some of these actually appear to peak in your early 40s, after which there is an ever-faster decrease in volume," says Dohm-Hansen.

The functional connectivity concerns the ways that the brain organises its processing – which regions work together at which time. In younger adulthood, the processing appears to be more modular: we have very distinct networks that work on specific jobs. In much the same way that a clear partition of responsibilities can enhance the performance of a sports team, this is thought to improve efficiency. Once again, in middle age, we start to see significant changes occurring. At this time, the brain's tight organisation starts to loosen up, with less segregation of the different networks. The magnitude of that change is strongly associated with your overall cognitive abilities and memory of everyday events, says Dohm-Hansen.

Like other forms of ageing, we each face an individual trajectory that may be markedly different from another person's. Some of this variation may be hardwired in our DNA. People who carry a particular version of the *apolipoprotein E* (*APOE*) gene are considerably more likely to develop Alzheimer's disease, for example. Research by Teal Eich at the University of Southern California and her colleagues shows that the effects of this gene are invisible until middle age, after which the consequences for episodic memory become increasingly pronounced.

Our genes don't seal our fates, however, with emerging evidence showing that the brain's path through middle age is intimately linked to our overall health – which can be modified by lifestyle factors.

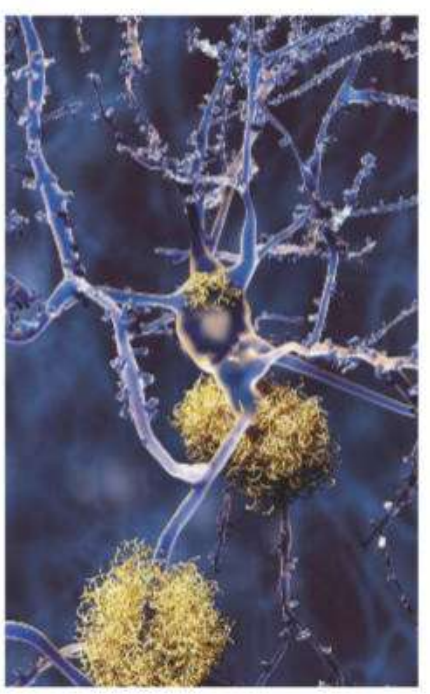
This tight coupling between body and mind was evident in one of Elliott's studies, published in 2021. Working with a global team of scientists, he examined the records of 1037 people born in Dunedin, New Zealand, between April 1972 and March 1973. The researchers chose 19 separate "biomarkers" that each indicate different elements of health as we get older, such as body mass index (BMI), hip-to-waist ratio, cholesterol, lung function, blood pressure, tooth decay and levels of an inflammatory molecule called C-reactive protein. "We wanted to measure ageing of the entire biological system," says Elliott.

From these individual measurements, the researchers could calculate a single score representing the wear and tear on the participants' organs – what they called a Pace of Aging (POA) score. These differed substantially from person to person, and they generally reflected outward signs of ageing. An individual's POA seemed to correspond with other subjective judgements of their physical appearance, for example: the higher the score, the older they looked for their age.

Could the POA scores also reflect the speed of people's neural decline? To find out, Elliott's team examined brain scans and tests of cognitive performance. The results revealed a tight link between the body and the brain, particularly in middle age. At around 45, participants with higher POA scores showed faster deterioration of the hippocampus and greater loss of white matter, for instance. They also showed a larger drop in general intelligence. "People who are ageing faster, on average, lost a few IQ points," says Elliott. "They were already losing a little bit of cognitive ability that might set the stage for things like dementia in old age."

The precise mechanisms are still under investigation, but there are lots of potential routes through which these bodily biomarkers could influence the brain's health. Obesity, high blood pressure and high cholesterol, for example, individually and collectively increase the chance that the brain's blood vessels become blocked or damaged, causing fluid to leak into the surrounding tissue, where it can harm neurons and their white matter – irreversible damage that begins in middle age.

Irreversible damage to brain cells (yellow) begins in middle age



JUAN GAERTNER/SCIENCE PHOTO LIBRARY/ALAMY

Turning point

Then there is inflammation. This is one of our body's vital weapons against infection, but only when it is used sparingly. Unfortunately, the immune system can sometimes go awry, pumping out inflammatory molecules when there is no immediate threat. Over time, this wreaks havoc in the brain, killing its cells and breaking their links, and it is thought to contribute to the build-up of protein plaques in Alzheimer's. "There's evidence that some of these inflammatory processes accelerate during the midlife period," says Dohm-Hansen.

The upshot is clear: if I want to start cultivating healthy habits, I had better start now, before the damage begins to accumulate. "From everything we know about the brain, it seems it's pretty hard to get back something

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that has been lost," says Elliott. "But you can prevent things from getting lost in the first place." And middle age may be an especially important time to take action, regardless of the lifestyle choices you have made previously.

That was the conclusion of the Lancet Commission on Dementia Prevalence, Intervention and Care, which examined the impact of various risk factors across the lifespan. It found that a few take on particular importance in middle age. For instance, while it is always advisable to manage our weight and control our alcohol consumption, the commission concluded that these behaviours have a particularly significant effect on our later dementia risk once we have reached our 40s. In other words, middle age is the prime time to cut down on the beers and burgers if we wish to preserve our minds later in life.

We might also get our ears tested. Following a conversation is a considerable mental workout and hearing loss can discourage us from engaging with others, depriving us of this cognitive exercise. "The easiest way to stimulate your brain is to just chat, and that makes your brain more resilient," says Gill Livingston, a professor of psychiatry of older people at University College London, who led the Lancet commission.

Danilo Bzdok at McGill University, Canada, who has studied the effects of our relationships on our brain structure and function, has similar advice. "I would argue that the most complicated processes that most people's brains compute on a daily basis is keeping track of and thinking about constantly changing social dynamics." This may help explain why loneliness is associated with an increased risk of dementia – but it is by no means the only reason. Social isolation can be a potent form of stress that triggers inflammation, for instance, resulting in poorer overall health. Many people find their social circles dwindling in midlife, so this might be a prime time to look for ways of connecting with your community.

Step it up

Last, but not least, we should watch our daily step count. It is now well known that exercise improves circulation and reduces inflammation in both the body and brain. It also triggers the release of brain-derived growth factor, a protein that helps maintain the health of our neurons and their links. As a consequence, maintaining a decent level of physical activity during middle and old age appears to slow the neural damage that typically accumulates with each passing year.

"Physical activity is very, very associated with a decreased risk of dementia in short and long-term follow-ups at all ages," says Livingston. "But fitness at midlife seems to make a particular difference."

This is good news for me. I have a BMI of 21 (in the "healthy" range) and – thanks to the flexibility of my working schedule – manage to walk or run more than 10 kilometres a day. I could try to increase that activity, but Dohm-Hansen warns that excessive exercise regimes may do more harm than good. "If you do too much of it, intense exercise can increase inflammation quite dramatically," he says. Maintaining moderate exercise is more than enough – and far more achievable for most people.

Public health campaigns have already improved middle-aged health and fitness in many different countries and this may be why we are seeing a noticeable difference in people's mental acuity. Although the total number of people getting dementia is rising with the increasing life expectancy of the world's population, the relative proportion of people developing the condition within each age group is shrinking – a ray of light that is often obscured in the popular discourse.

"This is associated with greater education, decreased cigarette smoking and decreased hypertension," says Livingston. The benefits for younger generations are substantial, with one analysis of data from the US and Europe concluding that the risk of developing dementia is falling by 13 per cent with each decade that passes. Livingston hopes that more targeted interventions will continue to build on these improvements. "It looks like there's an absolutely enormous possibility of decreasing dementia," she says.

Speaking to these scientists has certainly left me feeling a little more sanguine about the big 4-0. This change in mindset may itself improve my prognosis. As *New Scientist* recently explored, various studies show that people with rosier views of ageing tend to enjoy better health and a reduced risk of dementia in the years ahead. It may be that the positive attitudes encourage us to remain more active and reduce the sense of vulnerability that might set in as we get older, so we feel less stressed, all of which should enhance our mental and physical well-being. Whatever the reason, I am trying to see my 40s, 50s and 60s as a time of immense opportunity.

"When talking about middle age and its relevance to cognitive decline and neurodegenerative disease, it does kind of sound a bit doom and gloom," says Dohm-Hansen. "But it's important to note that it's part of the natural life course. The brain can start to leverage its compensatory mechanisms, and there's plenty of room for intervention." ▮

MARTIN PARR/MAGNUM PHOTOS

"Middle age is the prime time to cut down on alcohol to preserve your mind in later life"

David Robson's latest book is *The Laws of Connection: 13 social strategies that will transform your life*

THE SURPRISINGLY SIMPLE SOLUTIONS TO RENEWABLE ENERGY'S BIGGEST PROBLEM

Whether it is hoisting weights, melting salt or heating bricks, straightforward ideas could revolutionise the way we store renewable energy, finds **Roger Harrabin**

SOME 450 kilometres north of Helsinki, Finland, lies a decommissioned mine. Despite its remote location, it is being keenly watched because it looks set to play a role in revolutionising our energy systems – though not for the reasons you might suspect.

The Pyhäsalmi mine used to yield wealth from zinc and copper, but it is about to monetise the power of gravity. As the deepest metal ore mine in Europe, it is an ideal spot for what's known as a gravity vault. UK-based company Gravitricity plans to dangle a heavy weight down a mine shaft and connect the mechanism to a generator. It will store power as potential energy by pulling up the weight, then generate it again by letting it plummet.

If that sounds surprisingly simple, that is exactly the point. Governments are wrestling with the epic challenge of the intermittency of renewable power: how to keep the lights on when the wind doesn't blow and the sun doesn't shine. So far, they have largely focused on expensive technologies like hydrogen, nuclear power and lithium-ion batteries. But what if we could solve the problem of intermittency – and cut bills and emissions too – with far more rudimentary methods?

The gravity vault could be just the start. Other companies are developing energy storage methods that involve such technological marvels as salt, sand, water and hot bricks. These disarmingly straightforward technologies, it turns out, could provide the answer to one of the most pressing challenges of our time.

The amount of energy we generate from renewable sources is rising fast as we seek to cut carbon emissions in order to mitigate the worst effects of climate change. The US gets roughly 23 per cent of its electricity from renewables – that is, wind, solar and hydro – while for Australia the figure is around 32 per cent. The UK does even better, with about 47 per cent of electricity coming from renewable sources. But wind and solar power are notoriously intermittent. So, as we come to rely on these sources, we need a way of storing the power they generate in times of plenty to see us through the cloudy, windless days.

Lithium-ion batteries can do the job. However, even though their cost is tumbling, they are still expensive and, when used to store large amounts of power, they only work for a few hours before they begin to lose their charge. Facilities crammed with thousands of these batteries are popping up around the world, yet these mega-batteries have drawbacks, not least that they typically depend upon rare, expensive metals. Some of these, such as cobalt, are mined in awful conditions that raise serious human rights concerns.

Governments all over the planet are also keen on hydrogen as a way to store energy. The most environmentally friendly form, known as green hydrogen, is made using excess renewable energy to split water. The hydrogen is then stored, and burned cleanly later to produce electricity. It is a neat idea, albeit one propelled on a tsunami of PR cash from oil and gas firms. Such companies want to continue making money by producing hydrogen from their own extracted fossil fuels and then supplying it through the existing gas pipe network. The massive advantage of hydrogen is that it can store energy for long periods – proposals suggest the gas could be stored in underground caverns – and it will be a crucial part of our energy future. But masses of infrastructure will be needed to pipe it around, which makes it painfully expensive.

All of which explains why there is interest in less complicated solutions. One of the simplest ways to store energy is known as pumped hydro, which involves two lakes, one at the top and one at the bottom of a hill. Use cheap surplus electricity to pump water to the top lake, then allow it to flow downwards and turn a turbine when power is needed. It is extremely effective and relatively cheap. But not everywhere has a lake handy, and places that do tend to be scenic and rich in wildlife – not areas we particularly want to disrupt.

Gravitricity puts a fresh twist on the basic idea of harnessing gravity to store energy. Instead of using lakes and water, it plans to employ mine shafts like the one in Finland. There are plenty of them around. For instance, the company is also engaged in discussions to build its tech at sites in Germany and the Czech Republic. In 2022, it built an above-ground demonstrator rig with a couple of 25-tonne weights suspended by steel cables in Edinburgh, UK.

To be fair, not every community has an abandoned shaft nearby. But that isn't necessarily a dealbreaker for gravity-based energy storage. In 2020, Julian Hunt at the International Institute for Applied Systems Analysis in Austria and his colleagues suggested a gravity storage system based on a chairlift-like set-up, in which sand or gravel would be carted uphill, then allowed to race back down when electricity is needed.

"It's a twist on the basic idea of harnessing gravity to store energy"

It is too early to say whether the gravity-based ideas will really take off. But gravity vaults are far from the only simple energy storage solution in the offing.

Another idea is to take the concept of a battery and strip out the problematic bits. There are several variants on this theme, including batteries that replace costly lithium with cheap sodium. Massachusetts-based Form Energy has developed a rechargeable battery that relies on something equally mundane – rust. It works like this: when ›

PETER DAZELEY/GETTY IMAGES

charging, a current electrochemically converts iron oxide – rust, to you and me – into iron, and releases oxygen as a gas. When discharging, the battery sucks oxygen back in from the air and turns the iron back to rust, generating a flow of electricity.

Each of Form Energy's batteries is about the size of a washing machine – so not suitable for an electric car. But that is fine for grid-scale energy storage, where installations can cover large swathes of land. Form Energy says its rust batteries are optimised to store electricity for 100 hours at a lower cost than conventional batteries. Backed with more than $360 million in funding, the company has begun building its first battery factory in West Virginia.

We can't talk about making energy storage simpler, though, without talking about heat. According to the International Energy Agency, about half of the world's energy demand is actually for heat – to warm homes and offices and to power the industrial production of food, drink, chemicals, plastics and more. So instead of devising more gizmos to store and generate electricity, could we just store heat instead?

Thermal Energy Storage (TES) doesn't often make headlines, but a raft of firms have already caught on to its potential. Take Rondo Energy, based in California, which is developing products that store energy for several days in a huge stack of clay bricks sandwiched between two heating elements, like toast in a toaster. The idea is to hook up those heating elements to renewable energy sources and grill the bricks at 1500°C. The heat can then either be used directly in industry or to produce steam that drives a turbine and spits out electricity again. For Rondo Energy, it is a big step towards fighting climate change. "I get a deep sense of hope when I look at this brick," said John O'Donnell, Rondo Energy's CEO, in a recent talk, gesturing at one of the grey, heat-storing blocks on stage behind him.

These giant brick toasters would need to be located next to the factories they would serve, with heat being conveyed by an insulated pipe. The simplicity of the system makes it cheap: Rondo Energy estimates the cost of storing power this way to be about half that of green hydrogen. The company has already garnered $60 million in funding from Microsoft and the Saudi oil giant Aramco, among others. On top of that, the US government has given Rondo Energy up to $75 million to install its superhot brick batteries at two factories in Kentucky and Illinois owned by the drinks company Diageo. "This project will demonstrate an industrial heat and power model system that could be replicated in many other sectors," says Diageo's Marsha McIntosh-Hamilton.

Europe is also warming to heat storage, with one pioneer being the firm Kyoto. Despite being based in chilly Norway, it takes inspiration from the Noor power station near Ouarzazate in Morocco. There, a vast array of mirrors all reflect sunlight to the top of a tower, where it heats molten salt to around 1000°C – salt is used because it has such a high heat capacity. The stored heat generates power for the town, even after the sun goes down. Kyoto employs the same molten salt trick, but uses Norway's plentiful wind energy as the input.

The first working Kyoto system, known as a Heatcube – even though it looks like a tangle of pipes – has been installed at the Nordjylland Power Station near the Danish city of Aalborg. It can store heat for days at a time and release it as electricity to meet variable demands on the grid. In 2023, the system passed a key test designed to check that it could supply power at the required speed and consistency for the Danish electricity grid. Like Rondo Energy's bricks, the Heatcube can also double as a way to provide industrial heat. "With all the excitement about battery technology for electric vehicles, people have forgotten about the massive demand for heat for industries," says Kyoto's chief technology officer, Bjarke Buchbjerg. "Industrial heat is a big deal – we can't afford to ignore it."

So where do we go from here? It is important to recognise that no single energy storage technology is a panacea. We will need plenty of different options to meet our needs, depending on local geography and many other factors, and it remains to be seen which solutions come to fore. "There are lots of really interesting technologies that may have a role, but we still don't know which ones are going to succeed," says Simone Abram, director of the Durham Energy Institute in the UK.

That said, TES is having a moment. "Molten salt is going to be an important part of the energy mix," says Robert Barthorpe at the University of Sheffield, UK. "It's a fantastic technology, offering high temperatures at industrial scale."

Heat storage technology remains in its infancy and its affordability and efficiency is a slippery, contested matter. Yet we are also

GRAVITRICITY LTD

RONDO ENERGY

Gravitricty's demonstator rig in Scotland lifts and lowers two 25-tonne weights

Bricks for Rondo Energy's heat battery lined up at a production facility

"Instead of devising more gizmos to store electricity, could we just store heat instead?"

starting to get preliminary numbers on its costs. In a 2020 report, the International Renewable Energy Agency (IRENA) calculated the cost of TES using molten salt at around $22 to $26 per kilowatt-hour, whereas using hot bricks was $10 to $15 per kWh, depending on the scale and design. These costs are much lower than green hydrogen storage, which the US Department of Energy estimates at up to $50 per kilowatt-hour, largely because the infrastructure needed is so involved.

IRENA forecasts the global market for TES could triple in size by 2030, with investments reaching as much as $28 billion by the same date. In a February 2024 report, the environmental consultancy Systemiq said that deploying TES technology widely worldwide could cut energy-related greenhouse gas emissions by 14 per cent by 2050.

Despite piecemeal investment in TES, governments have been slow to get the message. Before the UK's recent general election, the Conservative government had announced plans to plough £21 million into several low-carbon hydrogen projects. But there has been little action on TES, which is cheaper. Moreover, the UK House of Lords science and technology committee published a report in March tellingly titled "Long-duration energy storage: Get on with it". It warned that the UK government lacks a robust plan to put in place long-term energy storage. "It is distressing to see that the [Conservative] Government lacks a clear plan for energy supply risks and indeed is still deliberating over investment in energy storage to prevent future crises," said Julia King, chair of the committee, at the time.

Fledgling TES companies are also finding it hard to raise their voice above the better funded nuclear and hydrogen industries. At the Innovation Zero conference in London in April, a UK minister said that, at times of low wind and sunshine, electricity would in future be provided by new nuclear power stations. The statement baffled energy experts, who pointed out that nuclear is the last technology that you would want to use for backup: it isn't the sort of thing you can turn off and on with the flip of a switch.

The sizeable backing provided by the European Commission, among others, for Rondo Energy's projects in Denmark and Germany suggests the picture is beginning to change elsewhere. But energy experts insist governments need to go further, with specific strategies for storing heat for industrial processes and grid-scale electricity storage. "Electrochemical batteries have their place," says Ian Arbon at the University of Strathclyde, UK. "But the current fad for massive installations of them does absolutely nothing – and never will – for the desperate need for medium-duration and long-duration energy storage."

Meanwhile, the simple energy storage concepts keep coming. Take Peter Dearman, a self-described "tinkerer" who became interested in sustainability at age 12. At the time, he was focused on using compressed air as an alternative to fossil fuels. It was a simple idea: use electricity to compress air into a super-cold liquid at -196°C (-320°F), store it in a tank and then warm and release the air to drive pistons.

Dearman has now been working on liquid air power for 50 years. In 2020, the firm he founded set up a pilot facility using liquid air to store power. It proved successful, so the next step is a larger facility that can store enough power to run 50,000 homes for 5 hours. Dearman says that if waste heat from a factory, say, is used to mobilise the super-chilled air, the system approaches the efficiency of batteries. "The beauty of liquid air storage is that it uses off-the-shelf simple technology made in the UK," says Dearman. "I'm confident it will play a role in our energy future." ▮

Roger Harrabin is a freelance journalist and an honorary fellow at St Catharine's College, University of Cambridge

‘We’re building a telescope bigger than Earth’

Alex Lupsasca is part of an ambitious plan to send a radio dish into space to image a nearby black hole. He tells Thomas Lewton how this could test the limits of relativity

WE ARE living in the era of black hole photography. In 2019, the first picture taken of a black hole was released. Unsurprisingly, it was difficult to get – in fact, it required a telescope essentially the size of Earth. Yet for researchers such as Alex Lupsasca at Vanderbilt University in Tennessee, that wasn’t good enough. He and his colleagues have set their sights on a more detailed image, but to get it we will need an even larger telescope.

The groundbreaking 2019 picture was taken by a network of radio observatories dotted around Earth, collectively known as the Event Horizon Telescope (EHT). Working together, eight of them created an image as clear as would a single dish larger than any that could actually be built. Lupsasca is part of a team planning to launch the Black Hole Explorer (BHEX) telescope, which would extend this network into space 20,000 kilometres from Earth – creating a receiver effectively bigger than the planet. Doing so, he says, would give researchers the precision needed to measure a mysterious part of a black hole known as a photon ring, in this case one created by M87*, the supermassive black hole in a nearby galaxy that featured in that first picture.

Lupsasca, the BHEX mission’s deputy project scientist, is a theorist who specialises in the physics of extreme environments, like the centres of black holes. He told us about why he thinks this is our best hope yet of breaking Albert Einstein’s theory of gravity and why ambitious space missions are the key to finally cracking one of the biggest mysteries in physics: the fundamental structure of reality.

PAUL RYDING

Thomas Lewton: Why do we need such a big telescope?

Alex Lupsasca: To observe a tiny object in the sky, you need to resolve rays that are very close to each other. If you have a bigger telescope dish, then you can bounce them off the dish and focus them more precisely. We want to take a sharp image of M87*, a nearby supermassive black hole, which has roughly the same size in the sky as an orange on the surface of the moon. We want to see what is called the black hole’s photon ring by making high-resolution movies of M87*. To do that, we need a dish that is bigger than the size of Earth.

Is the telescope really bigger than Earth?

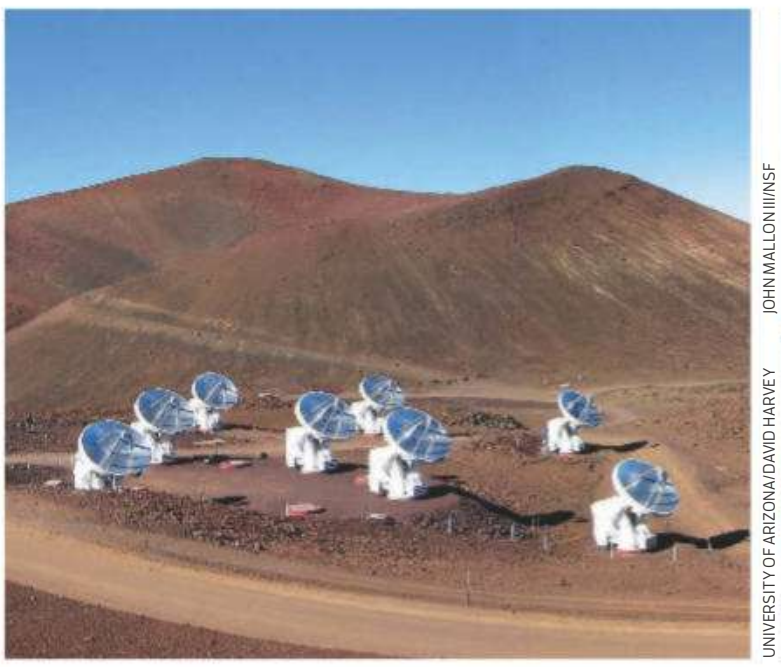
Imagine you have a big, mirrored dish and you shatter the mirror into shards, and then you carry the shards far apart to opposite sides of Earth and beyond. In each shard, you can only see a sliver of the black hole, but if you record that information very carefully, you can virtually bring the shards back together to reconstruct the full image. Given sufficiently many shards, this image has almost the same precision as a telescope dish that is bigger than Earth.

Has the Black Hole Explorer mission been approved by NASA?

Not yet, but in the past few months, we’ve made rapid strides towards that goal. We are ›

"Space missions like this are the cathedrals of our era"

ESO/M. KORNMESSER


J. WEINTROUB

JOHN MALLON III/NSF

UNIVERSITY OF ARIZONA/DAVID HARVEY

now working with NASA's Goddard Space Flight Center, and we've brought on engineers to figure out the remaining technical challenges. We've also raised private funding, including seed funding from tech investor Fred Ehrsam. We're running full steam ahead to put together a full proposal for NASA next spring. If that's adopted, then we'll get a satellite to fly in 2031, which feels far away, but in space mission terms that's not long at all. Hopefully before my hair turns grey, we can actually make a movie of a photon ring.

What is a photon ring?

Suppose there's some hot gas giving off photons around a black hole. Most of these swerve a little bit around the black hole's gravity, and these will show you an image of the gas around it – as in the EHT images of black holes. But there are a small fraction of photons that, if aimed just right, orbit exactly around the edge of the black hole, called its event horizon. This is the edge of our visible universe – we really have no idea what happens to particles that pass over its precipice, and perhaps we never will. So the photon ring is light that skirted the edge of our universe and then escaped [the event horizon], carrying information about the space-time geometry there.

The Event Horizon Telescope uses dishes (bottom three images) dotted around the world (top). Black Hole Explorer would extend this ground-based telescope network into space

Why do you want to measure the photon ring?

We want to explore how gravity works in the most extreme conditions imaginable. Gravity is by far the weakest of the four forces of nature that we're aware of. That makes it the hardest to measure. Its effects are the most subtle, the least well understood.

We have a perfectly good, internally consistent theory – called quantum field theory – for the other forces of nature, which are electromagnetism and the weak and strong nuclear forces. But it isn't fully compatible with Einstein's general theory of relativity, which is our best description of gravity. We want to be able to write down mathematical equations that describe all these forces together. But there is a tension – when we try to combine these two things, we find that they don't play well with each other.

So what can we do? We can look to black holes, which are, by definition, the most extreme gravitational fields that can exist. They are the best place to look to glean clues

about the next deeper layer of fundamental theory. These are pre-made experiments with strong gravity that we can study – and photon rings are a stamp placed on an image of a black hole by its strong gravity.

Can you describe the signature that the rings contain in more detail?

This first photon ring that we plan to observe with BHEX is created by light travelling towards the black hole that makes one half turn around the edge and then is sent on towards our telescopes. This is the brightest and outermost ring, but nested within it there are many fainter sub-rings. They are labelled according to the number of times that photons orbit around the black hole.

General relativity tells you that each ring is almost a perfect circle, but there is a slight deviation that follows a periodic pattern – the periodicity tells you about the diameter of the ring at that angle. It also tells you the precise relationship between these rings. Recently, Michael Johnson at Harvard University – who is part of the BHEX team – and I found that a single telescope orbiting Earth, looking at the photon ring from different angles, is all you need to measure this complex form. That isn't obvious; there's some mathematical magic at play here. Together, Johnson and I won the New Horizons in Physics prize for that result. Several of our colleagues, including Sam Gralla and Dan Marrone from the University of Arizona, have also done important theoretical work in this area.

Is the hope that the photon ring will deviate from general relativity?

BHEX's observations would be qualitatively different from all tests of general relativity that have been done on Earth or in the solar system so far, because they will really probe this strong gravity regime. So they give us a shot at seeing something totally radical and surprising. That's the aspirational goal of BHEX. If we're lucky, maybe some signature of something different from general relativity will appear, but I'm not holding my breath for it. However, we are guaranteed to learn a whole lot of exciting new astrophysical results about magnetic fields and matter falling into a supermassive black hole.

How hard is it to link up telescopes dotted across Earth to one in space?

The main issue is we need to record a lot of data. The EHT, which took the first black hole pictures, is an Earth-sized array of telescopes. Each one recorded petabytes [10^{15} bytes] of data. That was the most data-intensive experiment in history.

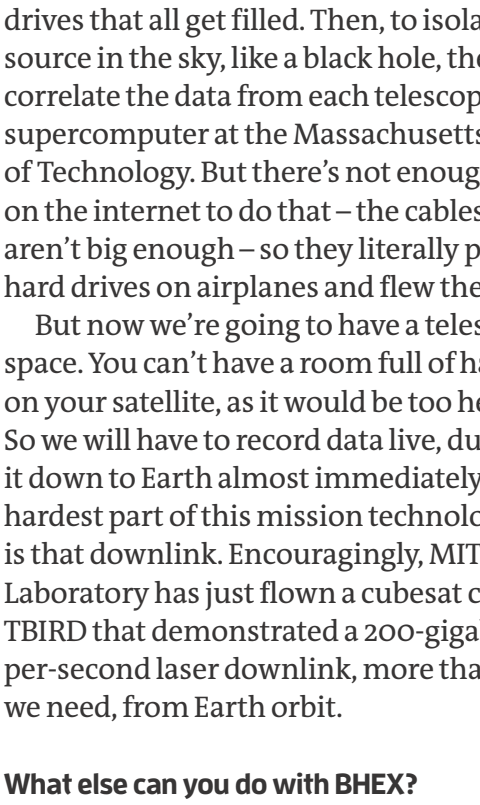
Imagine a big room filled with racks of hard drives that all get filled. Then, to isolate a tiny source in the sky, like a black hole, they had to correlate the data from each telescope using a supercomputer at the Massachusetts Institute of Technology. But there's not enough capacity on the internet to do that – the cables just aren't big enough – so they literally put the hard drives on airplanes and flew them there.

But now we're going to have a telescope in space. You can't have a room full of hard drives on your satellite, as it would be too heavy. So we will have to record data live, dumping it down to Earth almost immediately. The hardest part of this mission technologically is that downlink. Encouragingly, MIT's Lincoln Laboratory has just flown a cubesat called TBIRD that demonstrated a 200-gigabits-per-second laser downlink, more than we need, from Earth orbit.

What else can you do with BHEX?

We don't really have a good way of measuring spin for black holes, or even the black hole mass for that matter. It's really tricky. We know the mass of the black hole at the centre of our galaxy, Sagittarius A*, very well. That's thanks to Reinhard Genzel at the Max Planck Institute for Extraterrestrial Physics in Germany and Andrea Ghez at the University of California, Los Angeles, who measured the orbital motion of stars around the black hole over two decades. But for us, measuring the black hole will be as simple as putting a ruler across the photon ring.

The first images of the supermassive black holes M87* (top) and Sagittarius A* (bottom)



EVENT HORIZON TELESCOPE COLLABORATION

Black holes are thought to be described only by their mass and spin. This is called the no-hair theorem in general relativity [the idea that "hairy" black holes with more observable features, or "hair", are impossible]. So testing this by measuring the mass and spin of a black hole for the first time is a huge deal. The assumption that black holes really are described by general relativity underlies all of our models in astrophysics. It's a workhorse of astronomy, but it's something that we haven't really tested with great precision yet, at least for supermassive black holes.

What is the next step, after the first photon ring movie?

After seeing the first photon ring, the next thing will be to set a satellite even farther out, at a lunar distance. That will let us see the second photon ring, which you can now compare with the first one. Once you can see multiple rings, you have a super-sharp probe of general relativity. Each ring gives you an exponential bump in the precision of your test.

The 20th century was the century of the particle collider. Smashing particles together at high energies helped us figure out how three of the forces of nature work. But you're never going to smash particles hard enough to see how these quantum forces can be united with gravity. Recently, it has become much cheaper to launch sensitive instruments that can do this into space because of private space companies. I think 21st-century physics is going to be defined by the study of extreme phenomena in space.

The technology involved is just mind-boggling. I went to Paris recently and saw the Sacré Coeur, this ginormous cathedral. You go in and you see how the stones were erected, the ceiling is so tall, and you think, "wow, our ancestors built this, but what are we doing that's like this in our time?" Space missions like the James Webb Space Telescope and BHEX are pushing the envelope theoretically, experimentally, technologically. They are the cathedrals of our era. ▮

Thomas Lewton is a features editor at *New Scientist*

The back pages

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Twisteddoodles for *New Scientist*
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The science of baking

A very cool cake

For a dessert that taps into thermodynamics and provides a good physics lesson, try baked Alaska, says **Catherine de Lange**

Catherine de Lange is the editor of *New Scientist* and an avid baker

I RECENTLY watched the romantic drama *The Taste of Things*, in which there is much ado about a baked Alaska. This delicacy consists of sponge cake topped with a dome of ice cream, all of which is slathered with meringue that turns a gorgeous brown when cooked. The film's characters briefly muse over the science involved in keeping ice cream from melting within a cake as it is baked in the oven. As many of us are approaching school holidays, I would say this is also an easy, delicious experiment you can conduct with any restless children.

There are two things that are particularly fun about this cake. First is that you can really go to town on the ice cream filling, designing your own version, whether that is colourful layers of flavoured ice cream, adding fresh or frozen fruit, or a classic vanilla.

The second is, of course, the wonderful effect of cooking ice cream without it melting. The explanation for how this is possible is, as with so many things in baking, to do with eggs. As these are whisked to make the meringue, the proteins stretch and trap air bubbles within. As air is a poor conductor of heat, the bubbles in both the meringue and the cake below act as insulators, protecting the ice cream from the oven's heat.

To guarantee success, you need to get technical. The factors that will ensure your ice cream stays cold include the thickness of the sponge and meringue, as well as the temperatures of your oven and your ice cream. Luckily, this important scientific question has been investigated, and to bake the dessert at 200°C (400°F), you need to slather your meringue to at least 2 centimetres thick to ensure the ice cream doesn't melt.

SHUTTERSTOCK/BRENT HOFACKER

First, let's deal with the filling. Scoop slightly soft ice cream into a bowl lined with aluminium foil or plastic wrap, then cover it and put in the freezer until set (at least 5 hours). The base of the cake is traditionally a vanilla sponge, but again you can go wild and pick whatever type of cake you like. I'll leave that up to you. Ensure your sponge is at least 2.5 centimetres thick and cut it to match the size of the base of your ice cream dome.

Now for the meringue. Whisk the egg whites in a clean bowl, then add the dry ingredients (you can read my guide to perfect egg whites in my 11 May column).

When your ice cream, sponge cake and meringue are ready, it is time to assemble them. Remove the ice cream dome from your mould and put it on top of the cooled sponge, adding a layer of jam between the two if you like. Do all this quickly, on a baking tray lined with baking paper – as the ice cream needs to remain as cold as possible. Then spread the meringue over the top with a palette knife. Pop the assembled dessert into an oven preheated to 200°c/400°F, and bake for 8 to 10 minutes until golden brown. Serve quickly, to the delight of your guests/children. ▮

These articles are posted each week at newscientist.com/maker

What you need

Ice cream of your choice (about 500ml/0.9 pint)
Fresh or frozen fruit (optional)
A layer of sponge cake
Jam (optional)

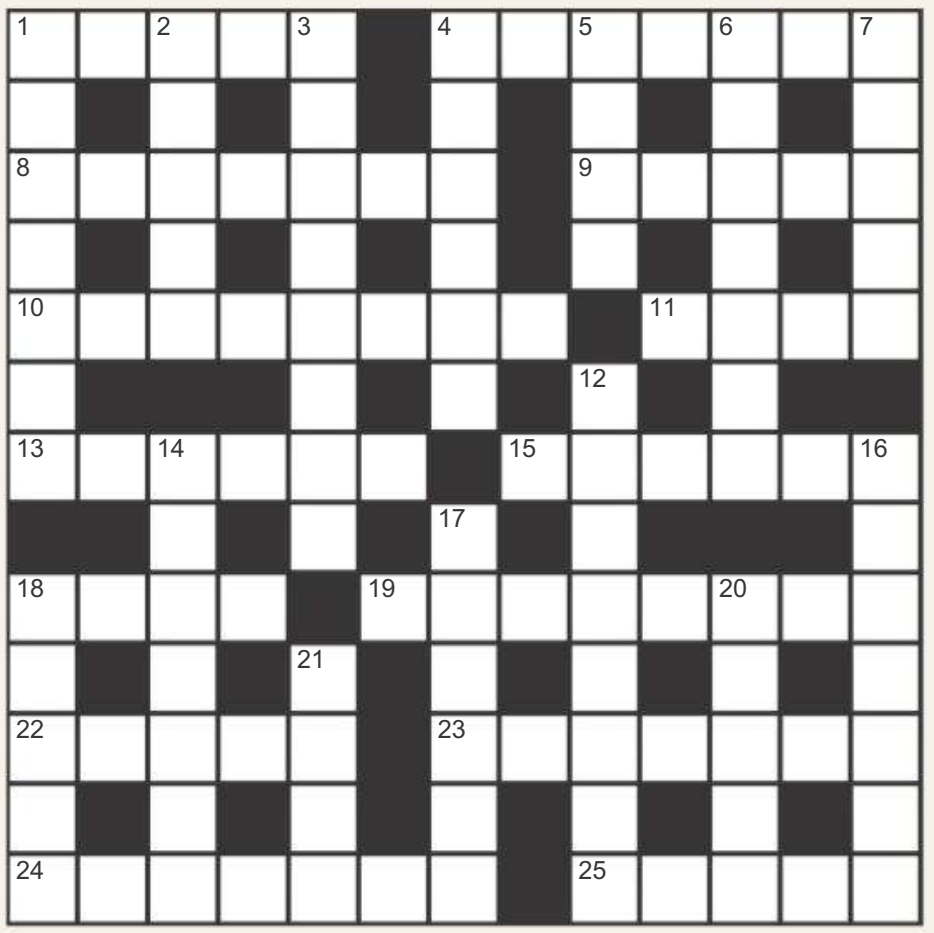
For the meringue:
4 large free-range egg whites
170g caster sugar (3/4 cup)
¼ tsp cream of tartar

The science of baking appears every month

Next week

Dear David

Cryptic crossword #140 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Frequency isn't commonly hard to hear (5)
4 Wedding attendant's behind grand blowouts (7)
8 Limit Mr Vicious's viral cases (7)
9 At an audition, our group will twirl (5)
10 University employee breaking ruler, etc. (8)
11 Tie secures large fuse (4)
13 Toady put small amount at first into Japanese money (3-3)
15 Note inverted avian vein (6)
18 Type of rock that's left in amalgam (4)
19 Quiet affair rejigged with no fuel (8)
22 Enough sulphur extracted from aliquot (5)
23 Tree spreading around volcanic formation (7)
24 Hilarious sort follows that female vet of literature (7)
25 Hoist weight 2.54 centimetres (5)

DOWN

1 Tip of chisel splits defective gift (7)
2 I boost a conservative authority on nomenclature (5)
3 Judgy people run IT lab badly (8)
4 Suddenly inspired, Georgia went too fast (6)
5 Scatters farm animals (4)
6 Specs finally include softwood vibration detector (7)
7 Declined to absorb old firm (5)
12 Looking unwell after first two in disco bar (8)
14 Skillets flipped each fish (7)
16 China constituent unified within party (4,3)
17 Costumed person starting to make fresh tacos (6)
18 Standard value raised in growth hormone chart (5)
20 Mostly worry over refrigerant (5)
21 Prepared current astrobiological investigators (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #261
set by Bethan Ackerley

1 Hyperkalaemia is the overabundance of what in the blood?

2 The chemical basis of the umami taste was first identified by whom?

3 Which of the following celestial objects is found in the solar system's main asteroid belt: Hygiea, Orcus or Makemake?

4 The process whereby a non-toxic species mimics the appearance of a dangerous or noxious species is known as what?

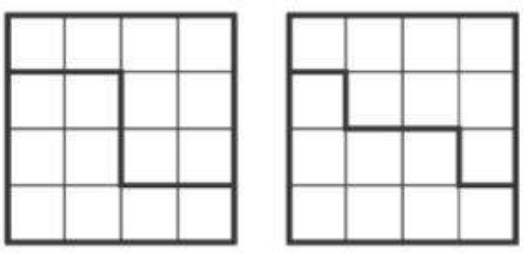
5 What does AIDS stand for?

Answers on page 47

BrainTwister
set by Howard Williams
#29 Four by four

By only cutting along the lines of a 4-centimetre-by-4-centimetre square grid, it can be divided into two halves of equal area and of identical shape. The simplest method for achieving this is a 4-centimetre cut, straight across the middle.

Ignoring rotational and reflectional symmetries, there are two ways (shown below) of using a 6-centimetre cut to divide the grid into equal areas of identical shape.



By making an 8-centimetre cut, can you divide the grid into two identical shapes?

With a 10-centimetre cut, it's possible to do this in two ways. Can you find both?

Solution next week

Take a breath

How did marine reptiles such as ichthyosaurs breathe?

Mike Benton
Professor of vertebrate palaeontology at the University of Bristol, UK
Like modern whales, the Mesozoic marine reptiles like ichthyosaurs and plesiosaurs had land-living ancestors. In the case of ichthyosaurs and plesiosaurs, these land-dwelling ancestors were probably something like lizards.

We know that the various ancient marine reptiles produced their young live at sea, as whales and dolphins do today. The fetuses developed fully inside the mother and were born straight into the water, where they rushed to the surface to take their first gulp of air.

The evidence that these reptiles produced live young at sea (rather than coming onshore to lay eggs, as turtles and crocodiles do) comes from dozens of fossils showing well-developed fetuses inside the mother's ribcage. Some even show something close to the moment of birth.

Although the ichthyosaur fossils don't show internal organs, such as lungs, we know, like all animals, they needed oxygen to survive. And in all other cases where land animals evolved to go back into the water (e.g. modern whales, crocodiles, marine snakes, penguins, seals etc.), they always breathe with lungs and don't evolve some form of gills as in a fish. They can all hold their breath – sometimes for significant lengths of time – but have to keep coming to the surface to breathe.

"Evidence that extinct marine reptiles produced live young at sea comes from fossils showing fetuses in the mother's ribcage"

We assume that it was the same for the ichthyosaurs and plesiosaurs too.

Jonathan Wallace
Newcastle upon Tyne, UK
Ichthyosaurs and other extinct marine reptiles would have been obliged to resort to the same solution as modern day marine reptiles such as turtles and marine mammals like whales, dolphins and manatees: they would have had to come to the surface to breathe air via their nostrils.

Sea snakes have the ability to absorb oxygen across their skin and this may help to extend the period they can spend underwater. But they are unable to obtain all the oxygen they need in this way and are obliged to surface periodically to breathe.

Alex McDowell
London, UK
Marine mammals, including whales, dolphins and porpoises, surface to breathe air – just like ichthyosaurs did.

When most dolphins sleep, only one cerebral hemisphere "powers down" and the other one remains active, thus they have sufficient consciousness to surface to breathe. Maybe prehistoric marine reptiles had similar mechanisms.

Patrick McDonald
Via email
Since they were reptiles and had lungs rather than gills, they would have had to surface, much as dolphins do today. Exceptional preservation would be needed to determine if they had evolved blowholes as well.

SHUTTERSTOCK/SOOS JOZSEF

This week's new questions

Top to bottom **Why, generally speaking, do large military planes have wings on the top of the fuselage, but on large commercial planes, they are on the bottom?**
***John Clark**, Leeds, UK*

Stop all the clocks **What would happen if time stopped?**
***Rodger Ewy**, Boulder, Colorado, US*

Why do large military planes have their wings on the top of the fuselage?

Whodunnit?

If visitors to our planet in millions of years found fossils of a *Homo sapiens* and another great ape in an elaborate tomb, would they be able to prove which one built it?

Abhranil Dasgupta
Kolkata, India
If extraterrestrial visitors have the ability to travel for multiple light years, they must have harnessed tremendous energy to accomplish this feat. This would make them a type II civilisation on the hypothetical Kardashev scale, able to harness the power of their star.

If this is the case, then we should also ponder their mental and physical prowess, such as their sense of intuition. Even a type I civilisation – one that can access and store all the energy on its planet – would be able to harness mental and spiritual abilities far greater than present-day humans. Who can say that civilisations that are type I or above can't reach levels of intuitive and cognitive capabilities that allow them to determine which remains in the tomb belong to which entity?

That, added to their potential technological advances, could lead them to ascertain the creator of the tomb via geological, biological and chronological tests.

Dog legs

Unlike me, my dogs bound up hills as easily as they run on the flat. Does having four legs aid with climbing, or are the dogs just fitter than me? (continued)

Keith Macpherson
Clevedon, Somerset, UK
Penelope Reid describes her different methods of locomotion, including the use of long staffs, which she describes as like two extra legs. Although fully mobile, I have a similar method of uphill walking that "feels" very energy

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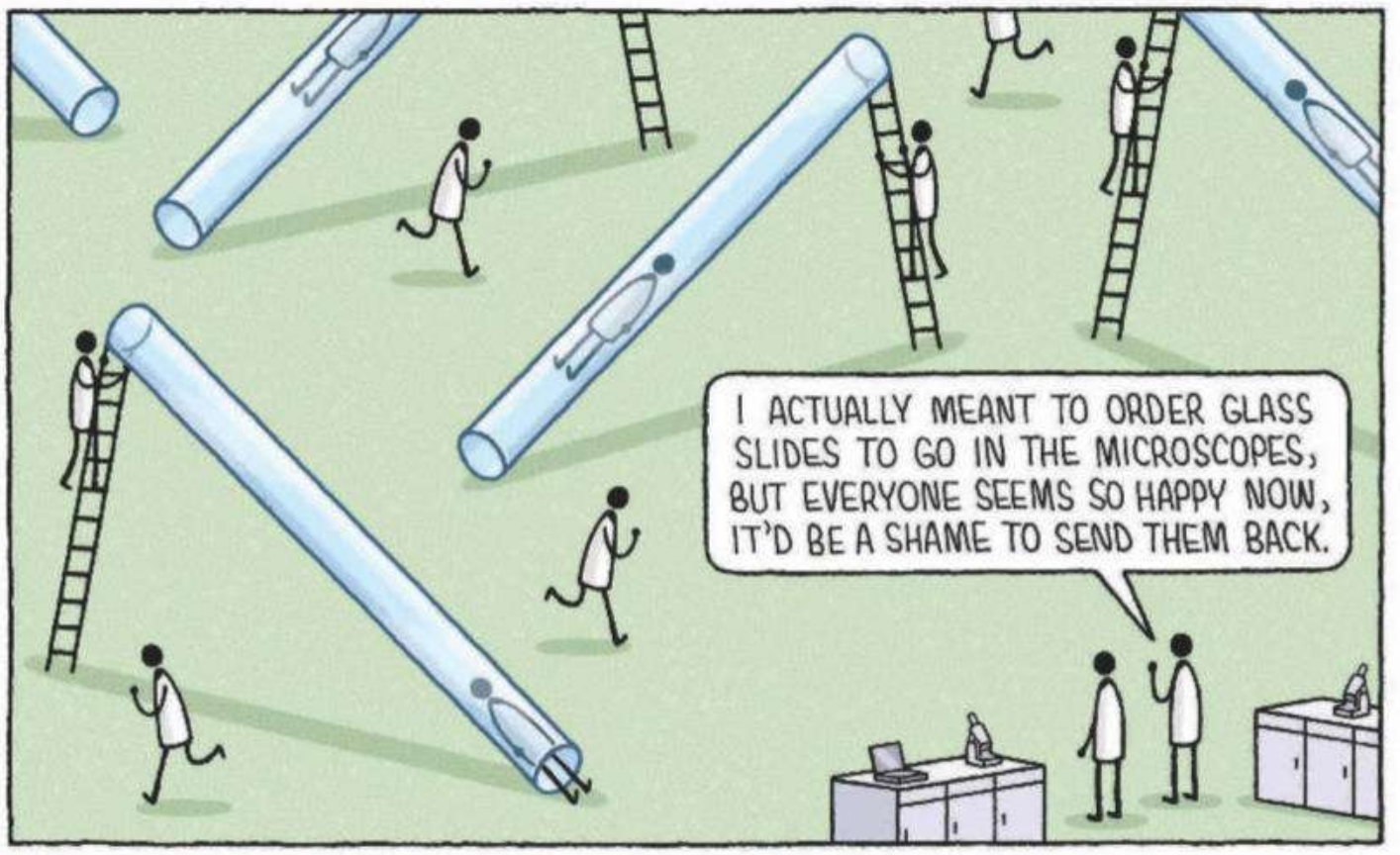
I ACTUALLY MEANT TO ORDER GLASS SLIDES TO GO IN THE MICROSCOPES, BUT EVERYONE SEEMS SO HAPPY NOW, IT'D BE A SHAME TO SEND THEM BACK.

efficient, but may just be my imagination. It is especially useful when carrying two heavy bags.

At the start of the climb, I move both arms forward, propelling the bags ahead of me, and begin walking. The bags and my arms are now pendulums. As the bags swing forward, they help to pull me up as I take my first steps. When they reach the top of the swing, they act like Penelope's staffs, giving me something to "hold" onto as I take my next step. I am then walking between the bags as they progress through the backswing. On their next upswing, I feel as if the bags are now helping to push me up. And repeat.

Height of change

As average sea levels rise, will contour lines and spot heights on maps need to be recalculated? If so, when? (continued)

Richard Ellam
Bristol, UK
Simon Ritchie's answer to this question mentioned that the

"The meridian marker at the Royal Observatory in Greenwich, London, has been deliberately moved at least twice"

meridian marker at the Royal Observatory in Greenwich, London, is in the wrong place. However, the meridian has been deliberately moved at least twice.

Historically, the Greenwich meridian was defined by extending the optical axis of the transit telescope at the observatory north and south to the poles. Because this transit telescope was needed for nightly observations to maintain timekeeping until a new one took over, when a better instrument was installed in the 1850s, it couldn't go on the exact same spot. Instead, the Airy Transit Circle telescope was put in a new enclosure about 8 metres east of the old telescope, which resulted in the meridian moving by the same amount eastwards. For all practical purposes, this minor realignment was irrelevant, and so passed without comment.

At the time, the observatory was under the aegis of the Admiralty. The Ordnance Survey was overseen by the Army Board, as it dealt in land-based mapping. In Victorian Britain, the army and navy had a somewhat strained relationship and tended not to share information.

In the 1860s, the Ordnance Survey decided to redo its primary triangulation of Britain. This map-making survey, which establishes a grid of accurately measured large triangles, had been done about a century earlier, and the Ordnance Survey wanted to do it again with improved instruments and techniques. To its consternation, the revised measurements showed the Greenwich meridian to be about 8 metres east of where it thought the line should be.

This was the cause of much worry, until the Admiralty fessed up to having shifted the meridian in 1854 when the new telescope came online at Greenwich! ▮

Answers

Quick quiz #261 *Answers*

1 Potassium
2 Kikunae Ikeda
3 Hygiea
4 Batesian mimicry
5 Acquired immunodeficiency syndrome

Quick crossword #162 *Answers*

ACROSS 1 Caustic potash, **10** Aorta, **11** Asymptote, **12** Bluetooth, **13** Zippy, **14** Nephron, **16** Six-hour, **18** Encodes, **20** Sorting, **22** Torus, **24** *Inception*, **26** Andromeda, **27** Yeast, **28** Potentiometer

DOWN 2 Air pump, **3** Shattered, **4** Imago, **5** Psychosis, **6** Topaz, **7** Scorpio, **8** Carbon neutral, **9** Dehydrogenate, **15** NHS Direct, **17** Xerophyte, **19** CB radio, **21** Imitate, **23** Spoke, **25** Cyano

#28 Dice differences *Solution*

The initial game isn't fair. There are 36 ways to roll two dice. Of these, 24 result in a difference of two or less; 12 have a larger difference. Under the adjusted rules, returning to the start requires at least three rolls – two moving one place left, and one two places right. As the counter is half as likely to move right but goes twice as far in that direction, movement is balanced between the players. But the player moving left still has an advantage, as they always get to use their full move. The player moving right may only need to go one space, but to do so they would have to move two spaces. In a three-space grid, the player going left will win 2/3 of the time; in a five-space grid they will still win 12/23 of the time, or around 52 per cent.

Splitting hairs

"Academics are often accused of 'splitting hairs'," David Taylor tells Feedback. "Well this year my team and I have done just that. We built a machine which can literally split a single hair from end to end. This is the first time that anyone has been able to split a hair in the laboratory under controlled conditions and thus quantify the phenomenon. Perhaps you were planning some exciting cosmetic treatment, like changing the colour of your hair or curling it? I can tell you whether it's going to give you split ends or not."

He and his team wrote up their adventure in a paper called "The biomechanics of splitting hairs", published in *Interface Focus*.

This built on research done in the 1980s by Y. K. Kamath and H.-D. Weigmann, who took a crack at minutely examining what happens when a strand of hair splits.

In a *Journal of Applied Polymer Science* paper called "Fractography of human hair", Kamath and Weigmann managed to restrain their excitement. They went only so far as to say "electron microscopic evidence suggests that fracture propagation occurs by secondary cracks generated as a result of stress concentrations building up at the periphery of the primary crack".

Twisteddoodles *for New Scientist*

THE TWO TYPES OF SPEAKER AT A CONFERENCE
MY TIME IS UP SO I'LL WRAP IT UP NOW
THANK YOU
I'M GOING TO KEEP TALKING UNTIL SOMEONE TACKLES ME TO THE FLOOR
SLIDE 25 OF 76
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com
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Consideration of items sent in the post will be delayed

Water from the remains

Researchers in Brazil looked for the remains outside a cemetery of the remains of people who are buried inside that cemetery. Their main question: are the decomposing bodies contributing nastiness to the region's deep groundwater? Elias Saba and his colleagues wrote it all up with a ghoulishly geeky title: "Evaluating the impact of a cemetery on groundwater by multivariate analysis".

The team took data from three "monitoring wells" dug in the cemetery and compared that with the local sewage water company's data about water in household cisterns in the neighbourhood. A round of multivariate analysis brought both good and not-so-good news.

Both within and without the cemetery confines, the researchers explain, the soil was absorbing most of the problematic body waste substances, "preventing surface contaminants from reaching the aquifer". That's the upside. Here's the but: "Water samples collected in areas outside the cemetery do not meet Brazilian standards for drinking water."

Drinking grandma

Off-water from our forebears isn't a new concern. Perhaps the splashiest look at the question came in 2008 in the *Journal of Environmental Health*.

Reader Russ Hodge sent Feedback a copy of the article, titled "Drinking grandma: The problem of embalming", by Jeremiah Chiappelli, a lawyer, and Ted Chiappelli, a health sciences professor at Western Carolina University, North Carolina.

The Chiappellis explain: "The modern practice of embalming replaces organic blood with various toxic and carcinogenic chemicals, particularly formaldehyde. Then the embalmed body is placed underground where, despite the casket, the body's fluids will inevitably leak into the groundwater... The initial reasons for the use of embalming and the rationale given for the continuance of the practice fail to justify the potential public health and environmental risks presented by embalming."

The Chiappellis also tell of research, done by others, as to why so many people in the US opt to embalm: "In states that require funeral directors to be embalmers or have embalming facilities, cremation rates decrease due to funeral director inducement."

Burying the hatchet

Nothing cuts the social ice in a strange pub quite as sharply as axe throwing. But the sport can bring hazards for some of the people who are exposed to it in a dutiful, professional way.

Word is out, from researchers Kusha Davar, Arthur Jeng and Suzanne Donovan, that blastomycosis is one of those hazards. Blastomycosis is a fungal disease "manifested as pulmonary disease" that can also affect the skin, bones and genitourinary tract.

Further detail is on display (including in colourful photographs) in the trio's study, "Burying hatchets into endemic diagnoses: Disseminated blastomycosis in a novel occupational exposure". The patient had been "working at an axe throwing factory upon moving to Los Angeles" where "his duties included chopping wood for customers to use".

This disease, Davar, Jeng and Donovan contend, "is not a routine diagnosis" in southern California. They surmise that the *Blastomyces* fungus was in the wood before it decamped into the patient.

Telltale titles

Here are two of the recent additions to Feedback's collection called The Title Tells You Everything You Need to Know:

"Impact of wet underwear on thermoregulatory responses and thermal comfort in the cold", which appeared in *Ergonomics* in 1994.

And "The possible pain experienced during execution by different methods", which perhaps brought surprise to readers of the journal *Perception* in 1993.

If you find an equally striking example, please send it (with citation details) to: Telltale titles, c/o Feedback.

Marc Abrahams

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Sandra K ★★★★★

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Chrissie M ★★★★★

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Eileen M ★★★★★

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